Letter No: 39/UJVNL/03/Director Projects/EE(C-SBR)/L-1 Dated:18/03/2021

यूजेवीएन लिमिटेड

(उत्तराखण्ड सरकार का उपक्रम)

UJVN LIMITED

(A Govt. of Uttarakhand Enterprise)

कार्यालय अधिशासी अभियन्ता (जानपद) सिरकारी भ्योल रूपसीबगड़ परियोजना, तामाधार, मुनस्यारी पिथौरागड़

Office of the Executive Engineer (Civil), Sirkari Bhyol Roopsiabagar HEP, Temadhar, Munsiyari,Pithoragarh

CIN No.U40101UR2001SGC025866

Director (I. A.), Ministry of Environment& Forest and Climate Change,
Vayu Wing, 3rd Floor, Indira Paryavaran Bhawan,
Jor Bhag Road, New Delhi.

Sub:- Submission of compliance to EDS for consideration of Environment Clearance for Sirkari Bhyol Rupsiabagar HE Project in Uttarakhand.

Ref: F.No. J-12011/12/2015-IA.I dated:- 27/01/2021

Respected sir,

Kindly take reference to Minutes of the 7th Meeting of the Expert Appraisal Committee for River Valley and Hydroelectric Projects held on 5th February 2021 through Video Conference vide which observations have been uploaded on MoEF website and EDS has been sought on PARIVESH portal.

In this regards, the requisite details as sought vide EDS alongwith documents is hereby submitted for kind perusal.

18/03

(Charu Lohani)
Executive Engineer (C)

अधिशासी अभियन्ता (जानपद)
सि०भ्यो०रुप०परि०, यू जे वि एन लि०
मुन्स्यारी, पिथौरागढ़

Copy to following for information:-

1. Director (Projects), UJVN Ltd, "Ujjwal", GMS Road, Maharani Bagh, Dehradun.
2. General manager (CDH&NP), UJVN Ltd, Ganga Bhawan, Yamuna Colony, Dehradun
3. Dy GM (E&M-SHP), UJVNL, Pithoragarh
4. Dy GM (Civil), I&P and Kishau, UJVN Ltd, Ganga Bhawan, Yamuna Colony, Dehradun

Point wise replies to the Additional Details Sought for Item No. 24.4 {Proposal No. IA/UK/RIV/130432/2019, & File No. J-12011/12/2015-IA I} as per 7th EAC Meeting, MoM dated 5th of February, 2021.

Point wise replies to ten queries raised is given hereunder:

Query No. 1-Approved Pre-DPR chapters on hydrology and Power Potential studies be submitted to the Ministry before EAC meeting along with the status of DPR approval.

Reply:

Copy of approved Pre-DPR chapters on Hydrology and Power Potential studies are submitted as **Annexure-I** and **Annexure-II** respectively. The status of DPR approval/clearances from various directorates is elucidated in **Table-1**.

Table-1: Status of DPR Approval/Clearances from Directorates of CWC/CEA

Sl.	Description	Status
1	Hydrological studies (Clearance from CWC)	Water availability series (10-Daily discharge) has been approved by CWC vide letter no.1/UTT/60/2014/Hyd(N)/131-33 dated 21.02 2017. Design flood has been approved by CWC vide letter no. 1/UTT/60/2014/Hyd(N)/303-305 dated 13.04.2017
2	Power Potential Studies (Clearance from CEA)	Power Potential Studies has been approved by CEA vide letter no. 207/I/2014/HPA/846 dated 21.07.2017
3	Foundation Engineering and seismic aspects (Clearance from CWC)	Site specific seismic design parameter report has been approved in 33rd meeting of National Committee on Seismic Design parameter held on 25.04.2018 in New Delhi vide letter no. 2/2/2017(Vol-I)/FE&SA/225 date 01.05.2018
4	Standing Technical Committee Clearance on storage vs. ROR	Clearance has been accorded by STC of CEA vide letter no. 4/I/2017-HEPR/STC/685 dated 12.12.2017
5	Inter-state matters (clearance from CWC)	Interstate approval has been accorded by CWC vide letter no. 02/06/ISM-2/2017/97-98 dated 12.02.2019 circulated by PAC, CEA vide letter no. 2/UTR/19/CEA/10-PAC/153 dated 12.03.2019
6	MOWR clearance on international aspects	International issues are not applicable. Proposal has been submitted for "No Objection certificate" vide no 1362/UJVN Ltd./03/Dir(P)/GM(C-NP) dated 11.09.2017 to Director (ISM-2), CWC

Query No. 2-Development of HEP from upstream and downstream of the project should be mentioned along the details sketch (FRL, longitudinal distance/free flowing area etc.).

Reply:

Two Hydro-electric Projects viz., Mapang-Bogdiyar (200MW) and Bogdiyar-Sirkari-bhyol (146MW), proposed on the upstream of Sirkari-Bhyol-Rupsiabagar HEP, have been cancelled by the Government of Uttarakhand and the DPR of the Rupsiyabagar-Kharsiyabara (260 MW), located on downstream is being revised. Therefore, presently no project is in line for DPR preparation/implementation. Therefore, the master plan of the projects located on the upstream and downstream cannot be submitted. The same shall be prepared once the project layout of upstream and downstream projects is freezed.

UJVN Ltd. has allotted the task of Cumulative Environment Impact Assessment (CEIA) study of Hydro Electric Projects on river Goriganga & its Tributaries in Uttarakhand to WAPCOS Limited. In this study a master plan for the project located in river valley will be prepared and recommendations of the report will be implemented on all the projects in the basin. Thus, presently Sirkari-bhyol-Rupsiyabagar HEP (120 MW) is the only project in advance stage in Goriganga sub-basin.

Query No. 3-The methodology and study period of Fish sampling/ Flora and fauna should be submitted.

Reply:

Methodology adopted for fish sampling has been described in section 3.9.6.5 of EIA report. Primary catch survey was conducted in to the main stem of Goriganga and its main tributaries viz., Ralam Gad and Pitti gad, located within the project stretch and its influence area. Survey fishing was carried out in three seasons (Pre-monsoon 2018.Monsoon2018 and Post-monsoon 2018) with the help of local fishermen using cast net. Previous studies/references viz., "Studies on Ichthyofaunal Diversity with special reference to Monthly and Seasonal variations of Fish Landings in glacial fed mountainous Goriganga River of Kumaun Himalaya, Uttarakhand, India" (Kumar A., Research Journal of Animal, Veterinary and Fishery Science, Vol. 2(4), 1-12, April 2014), was reviewed. State Fishery Department was also consulted to get previous fisheries records and their availability in different stretches of Goriganga river located in Project area and downstream. Fisheries data were also gathered from the ongoing CEIA Study of Goriganga sub-basin being caused by UJVN by engaging WAPCOS.

Methodology adopted for aquatic ecology has been described in section 3.3.3.3 of EIA report. An extensive survey of river on upstream and downstream of diversion barrage site shall be carried out with the intention to examine aquatic animal species the sampling was carried out during the Pre-monsoon, Monsson and Post – Monsoon as per MoEF guidelines. A total of 4 biological parameters were studied to assess the river water quality. Biological characteristics that were assessed involved the status of zooplankton, phytoplankton (suspended algae), periphyton (attached algae) and macro

invertebrates. Methodology adopted for floral study and faunal study has been described in section 3.3.3.1 and 3.3.3.2 respectively of EIA report

Query No. 4-Conservation plan for Schedule I shall be prepared and submitted to the Chief Wildlife Warden for approval.

Reply:

As per the point no. 7 of amended ToR provided to UJVN Ltd vide MoEF & CC letter no. J-12011/12/2015-IA. I(R) dated 13.10.2020, the Wildlife and Biodiversity Conservation & Management plan needs to be prepared in consultation with Forest Department and approval from the competent authority is required. Accordingly, the plan was prepared and submitted to Divisional Forest Officer Pithoragarh. The later vide his office letter no 1051/12-I dated 14.09.2020 provided the approval on revised Wildlife and Biodiversity Conservation & Management plan (after enhancing the amount) with the consent of competent authority. Now as desired, the Conservation Plan for Schedule-I species was submitted to Chief Wildlife Warden, Uttarakhand vide letter No. 51/UJVNL/03/Director(P)/GM (New Project) SBR, dated 2.3.2021 **(Annexure-III**). The latter has forwarded the Conservation Plan to DFO Pithoragarh for examination and further action. In compliance, DFO Pithoragarh vide letter no. 3704/12-1 dated 18-03-2021 has submitted his recommendation to CWLW.

Query No. 5-The minimum observed flow in the river to be compared with the proposed e-flow. What arrangements are proposed for real time monitoring of the compliance of the e-flow releases.

Reply:

Based on CWC approved flow series of 37 years (1977-78 to 2014-15) and as per provision under ToR, on the basis of 20% of average flow in four consecutive leanest months in 90% dependable year (1987-88), the e-flow for four consecutive leanest months (November - February), has been worked out as 1.87 cumecs **(**Table 3.31 of EIA report).

Table: Computation of Minimum Flow Requirement during lean period

Month	Period	90% Dep. 1987-88	% of ecological flow as per MoEF norms	Ecological flow in cumecs
November	I	11.1	20	2.22
	II	9.6	20	1.92
	III	9.6	20	1.92
December	I	8.7	20	1.74
	II	8.2	20	1.64
	III	8.8	20	1.76
January	I	10	20	2.00

	II	9.3	20	1.86
	III	9.3	20	1.86
February	I	9.5	20	1.90
	II	9.7	20	1.94
	III	8.6	20	1.72
			Total	**22.48**
			Average	**1.87**

As per observed discharge data site for Year 2015-16 to 2019-20 at G&D site at Rargiri (near barrage site), being maintained by UJVN, the minimum observed discharge is 8.32 cumec in first ten daily of February 2020 (Table)**.** This is compatible with the minimum discharge of 8.2 cumec corresponding to 90% dependable year (1987-88).

Table: Observed 10-Daily Flow Series at Rargari G&D Site (cumecs)

Month	Ten- daily	2015-16	2016-17	2017-18	2018-19	2019-20
November	I	58.78	54.73	42.93	56.99	149.01
	II	53.62	51.09	35.42	48.82	132.95
	III	47.58	43.32	30.50	40.00	103.32
December	I	23.34	*	23.21	28.32	60.85
	II	17.93	*	23.35	26.77	36.55
	III	15.51	*	20.02	19.02	21.74
January	I	16.85	17.96	15.86	17.45	12.79
	II	16.20	17.13	14.61	14.17	10.06
	III	14.68	17.02	16.02	16.31	9.52
February	I	15.37	15.46	14.89	21.86	8.32
	II	15.54	15.38	14.25	21.68	8.32
	III	15.29	16.06	13.76	21.21	8.44

NB. * G&D Site was not accessible and no observation made.

The e-flow during lean season and non-lean, non-monsoon period shall be released through under sluice bay and measured by setting up a calibrated open channel flow meter to be fitted at the end of d/s pier of under sluice and also at two intake structures to measure the discharge entering into intake. During monsoon period the e-flow shall also be released through other bays where calibrated open channel flow meter to be fitted at the end of d/s training walls and an online monitoring system shall be installed at control room to ensure the e-flow monitoring as per direction of MoEF&CC. Compliance details shall be submitted on regular basis to it and UEP&PCB.

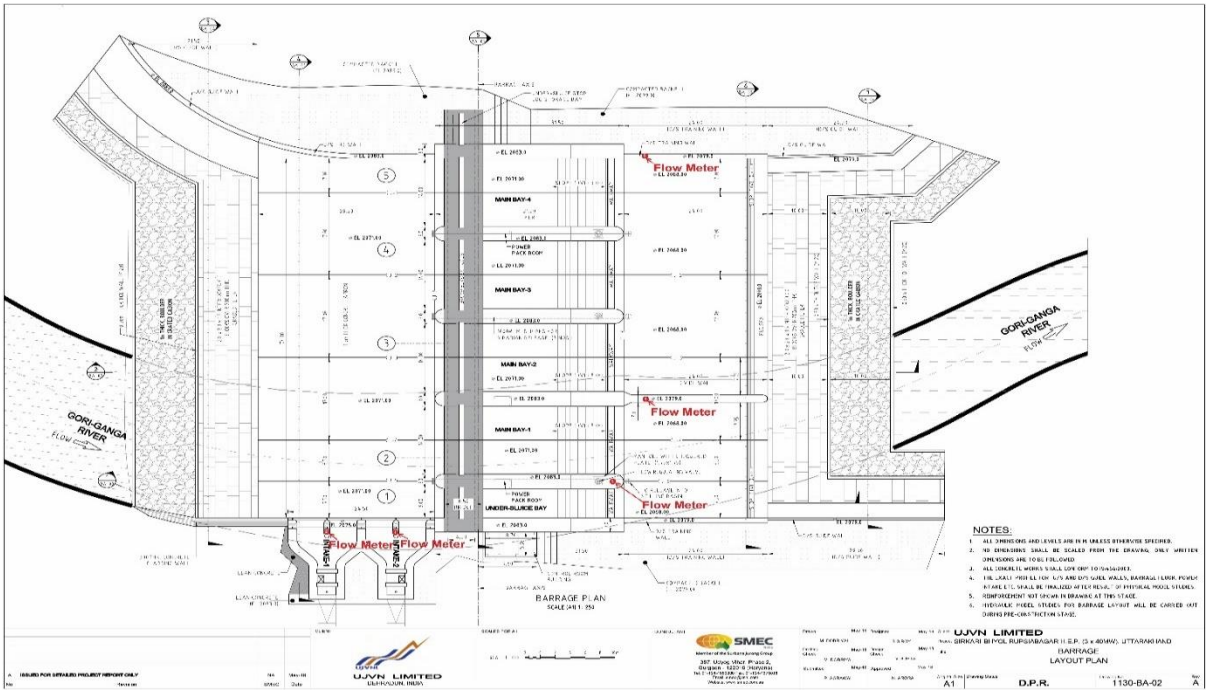


Figure 1: Location of Open Channel Flow meter

Query No. 6-Environment Cost Benefits Analysis should be revised considering cost of negative/positive impacts on all ecological entities in the region rather focusing on cost of impacts on human beings.

Reply:

Environment Cost Benefits Analysis is a useful tool to predict the damage caused to the environment by any development project in term of its impact of cost which can help management to take precautionary measure to minimize the damage and reduce the cost. The Environment Cost - benefit analysis (ECBA) has been carried out by considering impacts to various environmental entities like physical, ecological and social environment by reducing numerous complex physical, ecological and social-economic variables of environment to easy, quantifiable components of costs and benefits. Focus has not been only on cost of impacts on human being but includes impacts due to project., loss of forest land and the vegetal cover over it, of loss of eco-system services due to diversion of forests, loss of animal husbandry productivity, loss of fodder, habitat fragmentation, loss of soil-moisture, loss due to land degradation. Besides these factors, the impacts due increase in fugitive dust particles, impairment of quality of water, increased noise levels during construction, have also been considered in the analysis. The revised analysis is submitted in Tabular form as under.

Table: Environment Cost and Benefits Analysis

S.N.	Environment Cost/Benefit	MoEF Guidelines for CBA of forest land diversion,2017	Parameters	Total loss (Rs lakh)
A	**Environment Cost**			
1	Eco-system services losses due to proposed forest diversion	Economic value of loss of eco-system services due to diversion of forests shall be the net present value (NPV) of forest land being diverted	NPV of 30 ha forest land (eco-class-VI, dense forest) to be diverted @Rs 9.30 lakh/ha.	279.00
2	Loss of animal husbandry productivity including loss of fodder	To be quantified and expressed in monetary terms or 10% of NPV applicable, whichever is maximum	(i)30ha x Rs25070/ha = Rs7.52 lakh (ii) 10% of Rs 279 lakh = Rs 27.90 lakh. (Max. of two is adopted)	27.90
3	Cost of human resettlement	To be quantified and expressed in monetary terms as per R&R Plan	As per R&R Plan No resettlement is involved.	0.00
4	Loss of Public facilities and administrative infrastructure (Roads, buildings, schools, dispensaries, electric lines, railways, etc.) on forest land, which would require forest land if these facilities were diverted due to the project.	To be quantified and expressed in monetary terms as per actual cost basis at the time of diversion.	No public facilities on forest land are to be diverted	0.00
5	Possession value of forest land diverted	30% of environmental costs (NPV) due to loss of forests or circle rate of adjoining area in the district should be added as a cost component of possession value of forestland, whichever is maximum	30% of Rs 279 lakh (NPV) = Rs 83.70 lakh	83.70
6	Cost of sufferings to oustees	The social cost of rehabilitation of oustees (in addition to the cost likely to be incurred in providing residence, occupation and social services as per R&R plan) be worked out as 1.5 times of what oustees should have earned in two years had he not been shifted.	There are no oustess from forest land or private land, thus no social cost of rehabilitation of oustees is involved.	0.00
7	Habitat fragmentation cost	While the relationship between fragmentation and forest goods and services is complex, for the sake of simplicity the cost due to fragmentation has been pegged at 50% of NPV applicable as a thumb rule.	50% of NPV = 0.50x Rs 139.50 lakh = Rs 139.50 lakh	139.50

8	Compensatory afforestation & soil moisture conservation cost	The actual cost of Compensatory afforestation & soil moisture conservation and its maintenance in future at the present discounted value	Cost of Compensatory Afforestation& soil moisture conservation including maintenance cost =Rs719.0 lakh - Rs279.0lakh = Rs 440 lakh	440.00
9	Cost of conservation of Schedule-I wildlife and endangered plant species.	To be quantified and expressed in monetary terms based on actual cost of mitigation measures as per EMP.	Cost of Wildlife and Bio-diversity Management Plan=Rs 99.00 lakh	99.00
10	Cost of mitigating land degradation	To be quantified and expressed in monetary terms based on actual cost of mitigation measures as per EMP	Cost of Catchment Area Treatment Plan, Muck Management Plan, cost of Restoration of quarry area and landscaping plan, Reservoir rim treatment Plan =Rs lakh (595+1262+70+252) = Rs 2179 lakh	2179.00
11	Cost of impairment in air quality in project area and haul roads, increase in noise levels and impairment in surface water quality.	To be quantified and expressed in monetary terms based on actual cost of mitigation measures as per EMP	Cost of water, air, noise Management plan, Environ safe guard during road construction, Green belt Development Plan, Env. Monitoring Plan= Rs lakh (36+80+25+85) = Rs226 lakh	226.00
12	Cost of Environmental Management Plan for avoiding, mitigating, checking the adverse impacts on various environmental components during construction and operational phase of the project.	As per cost of EMP included in EIA report avoiding the cost of losses already included in serial No.1,8,9,10 and 11	Total cost of EMP after discounting cost included against S.N1,8,9,10 and 11.= Rs lakh (4105-279-440-99-2179-226) = Rs lakh	882
Total Environment Cost(A)				**4356.10**
B	**Environment Benefits**			
1	Increase in productivity attribute to the specific project	To be quantified and expressed in monetary terms avoiding double counting	After accounting for 12% free power to the state and 1% free power for local development of area, net annual Saleable annual energy (after accounting for 0.70% auxiliary consumption and 0.50% transmission loss) = 522.8 GWhX0.87 = 454.90 MU. The benefit expressed in monetary terms shall be for 454.90 MU @ levelized tariff of Rs3.31/unit.	15057.19
2	Benefits to economy due to specific projects	The incremental economic benefit in monetary terms due to the activities attributed to the specific project.	Establishment of project will facilitate the emergence of industries, trade and commerce and would bring more and more economic development in the State and Country At present the industry sector alone	4369.64

			consumes 42% of total consumption of the state. Therefore, on a conservative estimate about 219.58 GWh shall be consumed in industry. Since the tariff for mixed industry in the state is Rs 5.30/unit, which implies that the difference of Rs 5.30-3.31=Rs 1.99/unit shall accrue as an additional income of Rs 4369.64 lakh to the state.	
3	Number of Populations benefit due to specific project	As per DPR	The project will directly benefit the population of the country as a whole and the population of state, due to share of 12% free power and people of the project area by 1% free power for local development of area. The benefit expressed in monetary terms shall be for 522.8x0.13=67.96 MU @ levelized tariff of Rs3.31/unit	2249.48
4	Economic benefits due to direct and indirect employment due to the project.	As per DPR	(i) During peak stage of construction, employment will be generated for 1000 skilled/semi-skilled/unskilled labour. Assuming that on an average 500 persons are employed with an average minimum wage of Rs 9383/-pm after discounting the income of Rs 4000/pm by the person being earned before being engaged in construction, the net benefit shall be =Rs 5383x12x500= Rs322.98 lakh. (ii) After completion during operation about 50 people will get employment for O&M, routine upkeep / maintenance of roads and buildings. Average benefit shall be 25x12x25000=Rs75 lakh	322.98 75.00
5	Economic benefits due to compensatory afforestation	Benefits from such compensatory afforestation accruing over next 50 years monetised and discounted to the present value should be included as benefits of	Benefits from Compensatory afforestation in 60 ha @ discounted rates of 6% /yr. of NPV (Rs 8.97x60=Rs 538.2 lakh)	24.40

		compensatory forestation. For benefits of CA the guidelines of the Ministry for NPV estimation may be consulted		
Total Environment Benefits (B)				**22098.69**
Total benefits due for useful life of 40-year =40x (15057.19+4369.64+2249.48+75+24.40) +322.98				**871351.38**
Environment Benefit Cost Ratio= 871351.38/4356.10				**200.03 :1**

Query No. 7-Air and water analysis results may be re-checked and updated in EIA report.

Reply:

Baseline data for air quality for three seasons, as enumerated in Table 3.8 through 3.10, has been rechecked and no anomaly/discrepancy has been observed. Factually, during presentation against contents of slide No.19, it was pointed out how such a low concentration value was measured in case of SO_2. It was clarified that the 24-hourly maximum concentration value is not a measured value, but it is a predicted value of concentration for the pollutant and the word predicted has not been stated in the title of Table 4.3. The omission has been rectified now.

As regards water quality analysis results in respect of BOD, it is vividly mentioned in section 3.7.3 of EIA report that in respect of all surface water samples for three seasons BOD values ranged between 0.4 to 0.9mg/l and were less than 2mg/l and satisfy CPCB Water Quality Criteria i.e., Designated- Best Use Criteria (DBU) for Class A water.

Factually query was raised in respect of the Effluent Discharge Standard mentioned under slide N0.30. Under section 4.4.11 of EIA report it has been categorically mentioned that the effluent to be discharged should conform to the Standard adopted vide GSR1265(E), dated 13.10. 2017 (Table 4.1), according to which the BOD concentration in effluent discharge through STP should not exceed 20 mg/l, the standard set for Metro cities and all state capitals with the exceptions of states mentioned therein. The concentration not to exceed 30mg/l for areas/regions other than mentioned earlier. Since the project area neither falls under any metro city nor under state capital, the limiting concentration shall be 30mg/l.

Table: Effluent Discharge Standards for STP

Parameter	Standard	
	Location	Concentration not to exceed
pH	Anywhere in the country	6.5-9.0
Bio- Chemical Oxygen Demand (BOD)	Metro Cities, all State Capitals except in the state of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Sikkim, Himachal Pradesh, Uttarakhand, J&K, and UT of Andaman and Nicobar Islands, Dadar and Nagar Haveli, Daman and Diu and Lakshadweep	20

	Areas/regions other than mentioned above	30
Total Suspended Solids (TSS)	Metro Cities, all State Capitals except in the state of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Sikkim, Himachal Pradesh, Uttarakhand, J&K, and UT of Andaman and Nicobar Islands, Dadar and Nagar Haveli, Daman and Diu and Lakshadweep	<50
	Areas/regions other than mentioned above	<100
Fecal Coliform (FC) (MPN/100ml	Anywhere in the country	<1000

Source: GSR1265(E), dated 13.10. 2017

However, the PP is bound to comply with the new /revised standards as when notified by the MoEF&CC in pursuance with the direction passed by the Hon'ble NGT.

Query No. 8-Certificate from the CWLW that all the components of the project are outside the Askot Wildlife Sanctuary (WLS) or any other WLS.

Reply:

The arial distance of project boundary from nearest Askot WLS is 21.4 km, was already certified by the Competent Authority vide letter No.1145/32-1-1(GIS), dated Dehradun, 30.12.2020. Now as desired, Chief Wildlife Warden, Uttarakhand, vide letter No. 52/UJVNL/03/Director(P)/GM (New Project) SBR, dated 2.3.2021 **(Annexure-IV**), has been requested to issue the certificate. The latter, vide letter No. 9182/12-1, dated 3.3.2021, has forwarded the case to DFO Pithoragarh for examination and further action. The final certificate from the CWLW to the effect that all the components of the project are outside the Askot Wildlife Sanctuary (WLS) or any other WLS, is still awaited and shall be submitted after it is received. In compliance, DFO Pithoragarh vide letter no. 3703/12-1 dated 18-03-2021 has submitted his recommendation to CWLW.

Query No. 9- Sketches showing the arrangement of the proposed de-silting arrangement of the quarry water to be provided by the PP.

Reply:

In order to intercept sediment laden runoff from mined out areas of rock quarry site and trap the sediment, settling tank/sediment trap have been proposed. The dimension of the tank shall be 9.3m (long) x 2.5m (wide) x1.8m (deep) and shall be constructed by excavation and lining sides and bottom with 10cm thick cement concrete and with one baffle wall and an outlet discharging into connecting drain. The sketch of settling tank is shown in Figure-2. The cost of one such structure involving 4 cum cement concrete @Rs 4000/cum works out Rs 16000.00 and cost of excavation in rock for 20 cum @Rs 400/cum works as Rs. 8000.00 and the with cost of outlet, the total cost of one tank shall be Rs 25000.00. Therefore, cost of 4 such tanks shall be Rs 1.00lakh.

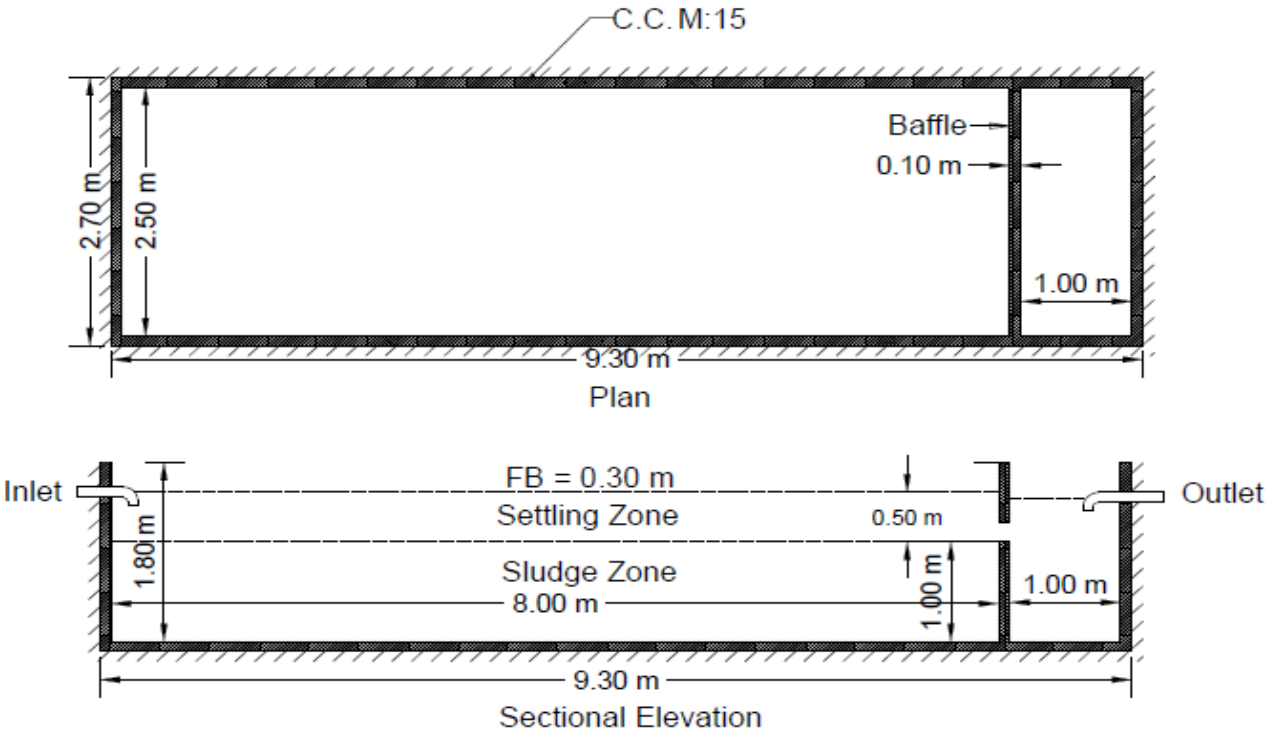


Figure 2: Sketch of Sedimentation Tank

Query No. 10-For the muck disposal arrangement, it should be certified that a proper slope stability analysis of the dumped muck pile has been done and the requisite engineering measures evolved accordingly.

Reply:

The Undertaking by the Project Proponent regarding the slope stability of muck piles and for implementing the engineering and biological measures to stabilize the profile of muck slope and it's close monitoring as per relevant rules/norms, is submitted as **Annexure-V.**

List of Annexures

Annexure – I: Pre-DPR chapters on Hydrology

Annexure – II: Pre-DPR chapters on Power Potential studies

Annexure – III: Copy of Letter submitted to CWLW for approval of Conservation plan for Schedule-I species

Annexure – IV: Copy of Letter submitted to CWLW that all the components of the project are outside the WLS

Annexure – V: Undertaking by the Project Proponent regarding the slope stability.

Annexure – I: Pre-DPR chapters on Hydrology

6. HYDROLOGY

6.1. INTRODUCTION

Uttarakhand the 27th state carved out in India on 9th November 2000 from Uttar Pradesh is generally called as the "Land of the Gods" due to many holy shrines, temples and pilgrimage centers of the Hindus. The state borders with China on the north, Mahakali zone of the far western region Nepal on the east, state of Uttar Pradesh in the south and the state of Himachal Pradesh in the northwest. The Uttarakhand state is divided into two divisions i.e., Garhwal and Kumaon and it is proven for its natural beauty. The state stretches from snow capped mountain ranges in the north to the plains of Ganga river in the south. In fact two of the most important rivers in Hinduism originates in the state i.e., Ganga at Gangotri and Yamuna at Yamnotri. The state due to the hilly terrain along with the rivers and their tributaries offer favorable sites for hydro-power development. In fact proposed project is located on Goriganga river, a sub tributary of Ganga River.

The present report on hydrology for the proposed project viz. Sirkari Bhyol-Rupsiabagar HEP indicates the hydrological studies carried out for this project utilizing the available hydro-meteorological data in the region. The hydrological inputs play a vital role in planning, execution and operation of water resources development project. The hydrological studies are carried out at all stages of project development starting from the pre-feasibility stage and are continued even during the operation of project. Hydrological studies usually cover the assessment of available water and its time variation, estimation of design flood usually required for the hydraulic design as well as safety of the structure and sedimentation studies. These are important for life of the project as well as its effect on the live storage. However for run-of-river projects where live storage is less, sedimentation studies are not essential as generally pondage is small due to storage behind the gates. The silt deposited behind the gates gets flushed out during monsoon season when generally all gates are open.

6.2. GORIGANGA RIVER BASIN

The Goriganga river originates from Milam glacier in Himalayas at an elevation of 3600 m and after flowing for 92 km in south- south east direction joins (Maha) Kali river about 1 km downstream of Jauljibi G & D site of CWC. After confluence, the river is called as Sarda river which joins further downstream with Karnali river and is called as Sarayu in Bahraich district, Uttar Pradesh till it joins Ganga river.

Goriganga originates from Milam glacier north east of Nanda Devi is fed from several streams flowing from the eastern slopes of Nanda Devi sanctuary and also from those flowing west from the high peaks of Panchuchuli, Rajramba, Ralamgad. The Kalabaland-Burfu Kalganga glacier system rivers also flows into the Goriganga valley from the east. The catchment area of river Goriganga lies between $29^0$45'N to $30^0$36'N and $79^0$59'E to $80^0$28'E and lies on the southern slopes of Himalayas. The area is

bounded by ridges and peaks rising upto 6000 m elevation which are permanently covered under snow and glaciers.

The village of Milam is located about 3 km from the snout of Milam glacier. The catchment area of the proposed project contains 29 glaciers. The river slope in upper reaches is very steep i.e., 1 in 19 while in the middle reach between Rupsiabagar to Bangapani it is 1 in 37. However in the lower reaches up to Jauljibi from Bangapani is approx. 1 in 68 while the average slope is 1 in 22.5. Due to the presence of glaciers, steep slopes, extreme cold weather prevails with extreme inhospitable and difficult conditions. Goriganga is perennial in nature due to contribution of snow melt.

6.3. PROJECT PROPOSAL

The proposed project is a run-of-river scheme which envisages construction of a barrage 12 m high with underground power house on right bank across Goriganga River with an installed capacity of 120 MW (3x40) in Pithoragarh district of Uttarakhand state. The diversion structure is located at latitude $30^0$11'6"N and longitude $80^0$14'16"E.

The entire catchment area of the proposed project lies between $30^0$00' to $30^0$36'N latitude and $79^0$59' to $80^0$17'E longitude and intercepts an area of 957 km^2 of Goriganga river. Several glaciers are located in the catchment area. An index map indicating the location of proposed project is at **Plate-I**.

6.4. PHYSICAL AND GEOGRAPHICAL FEATURES

The entire catchment of proposed Sirkari Bhyol-Rupsiabagar HEP is located in the catchment of Goriganga which originates from Milam glacier. The area is surrounded by high ridges and snow covered peaks. The snow covered peaks surrounding the valley form part of Nanda Devi mountain ranges. The elevation in the catchment ranges from 6000m in upper reaches to around 2180m near the dam site. The entire catchment of Goriganga lies in the state of Uttrakhand and is located between latitude $29^0$45'N to $30^0$36'N and longitude $79^0$59'E to $80^0$28'E

6.5. CLIMATE

Cold weather conditions exists through out the year. The summer are pleasant but nights are very cold due to icy winds descending down from high mountains. In winter extreme low temperature prevails with day temperature (maximum) varying between 5^0C to 10^0C. During night the temperature goes down below freezing point. Extreme weather is experienced during and after the passage of western disturbances when the temperature falls to as low as minus 20^0C to 30^0C. During summer the day temperature varies between 15^0C to 20^0C.

The precipitation occurs both due to South-West monsoon and western disturbances. Local thunderstorms also affect the weather of the basin. Due to steep and high mountain ridges, the valley is protected from the monsoon winds from both eastern and western

side and is affected by the winds that move up the valley only from lower elevations and also from area beyond the project region. Thus low precipitation is experienced with higher elevations. The average annual precipitation of the catchment is 2500 mm.

During winter the western disturbances are responsible for inclement weather in the area, but being on the leeward side of Nanda Devi mountains, the region receives heavy precipitation at the top. During winter season precipitation is in the form of snowmelt.

IMD had published the climatological parameters of its stations based on the observations carried out during the period 1951 to 1980 at several stations in the country. Though no such station data was available from IMD yet the climatological data of Munsyari Milam located at an elevation of 3414m and Askote station are available. The climatological parameters observed at Munsyari Milam indicates that winter precipitation during the period of January to April is 418.7 mm as compared to monsoon precipitation of 291.7 mm during the period of June to September. June experiences least rainfall during monsoon period and even in the month of May, the precipitation is higher than that experienced during the month of June. The details are given below in **Table 1.1**:

Table 6.1: Climatological Data at Munsyari Milam

(Station: Munsyari Milam) Latitude: $30^0$07'N Longitude: $80^0$15'E Altitude: 3414 Metres

Month	Air Temperature (^{0}C)		Relative Humidity (%)	Rainfall (mm)	
	Dry Bulb	Wet Bulb		Average Monthly	Heaviest in 24 Hours
January	5.8	2.5	63	189.5	114.2
February	7.1	3.6	60	117.8	79
March	10.8	6.2	55	63.6	50.2
April	16.0	10.6	55.5	47.8	50
May	18.5	12.7	56.5	22.8	61
June	19.3	16.0	72	18.2	40.6
July	18.7	17.4	88	75.4	79.9
August	18.3	17.2	89.5	73.4	53.2
September	17.2	15.6	85	124.7	126.2
October	14.3	11.1	74	11.9	40.9
November	10.5	6.9	64.5	7.8	14.6
December	7.7	3.8	55.5	25.4	45
Total				**778.3**	

Source : IMD Climatological Tables, Based on Observations from 1951-1980.

Climatological data of Askote IMD station located at 1468m elevation in the region and nearer to the project is also available. Due to altitude difference, the average rainfall recorded during winter precipitation is only 161.8 mm as compared to monsoon precipitation of 2188 mm. heavy precipitation occurs during the month of July and August. The situation is different at these two stations.

Table 6.2: Climatological Data at Askote

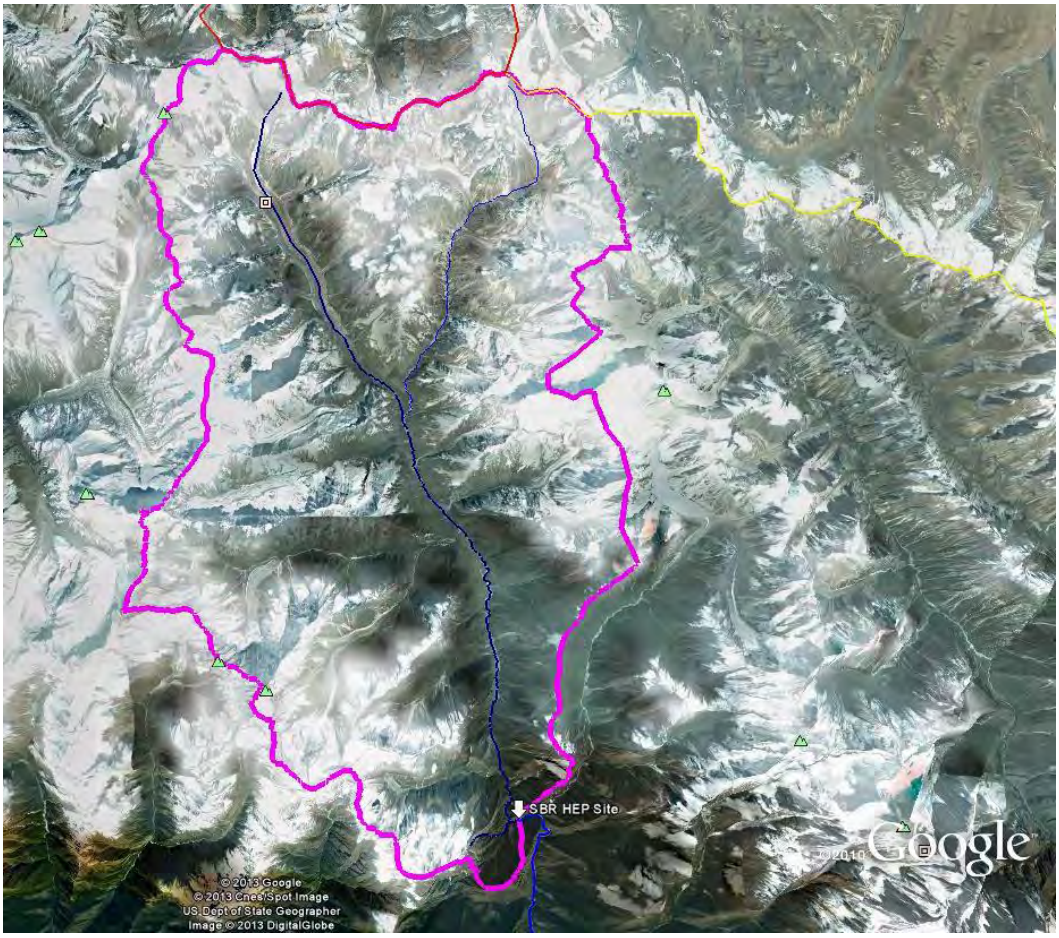
(Station: Askote) Latitude: 29^{0}46'N Longitude: 80^{0}20'E Altitude : 1468 Metres

Month	Air Temperature (^{0}C)		Relative Humidity (%)	Rainfall (mm)	
	Dry Bulb	Wet Bulb		Average Monthly	Heaviest in 24 Hours
January	8.6	5.9	71	49.3	46.4
February	10.6	7.5	70	57.8	44
March	14.2	10.7	69.5	60.7	77.2
April	19.6	14.6	65	51.3	55.1
May	22.2	17.3	68	92.4	136
June	22.7	19.1	74.5	436.2	248.8
July	24.7	22.9	86	700.6	404.2
August	25.4	23.8	87	692.3	149.3
September	23.6	21.5	82.5	359.8	149.8
October	21.0	18.0	73	57.9	76
November	16.4	12.9	69	7.4	31
December	12.6	9.5	71	20.2	36.8
Total				**2585.9**	

Source : IMD Climatological Tables, Based on Observations from 1951-1980.

6.6. CATCHMENT AREA

The Digital Elevation Model (DEM) data available through Google Earth, toposheet in the scale of 1:250000 of Survey of India was utilized for delineation of the catchment area and estimation of catchment parameters. Since Google data are available in the public domain and can be downloaded through internet and the facility is available through Google Earth, the same was analysed to assess the catchment area for the proposed Sirkari Bhyol-Rupsiabagar HEP site. The same was corroborated with the available toposheets. The proposed project based on the two studies reveals that it intercepts an area of 957 Km^2 including 526.48 Km^2 under permanent snow cover (permanent snowline considered at an elevation 4572 m). The catchment area lies between latitude 30^{0}09'N to 30^{0}36'N and longitude 79^{0}59'E to 80^{0}17'E. The catchment area map is at **Plate-II**, while Google Earth Image is indicated below:



6.6.1. HYPSOMETRIC CURVE

This curve is useful for assessing the hydrological variables that vary with elevation e.g., rainfall and snow cover. It indicates the area bounded between various elevations of the project catchment. The details of elevation-area relation for Sirkari Bhyol-Rupsiabagar catchment is given below in ***Table 1.3*** while the Hypsometric curve is shown in ***Fig. 1.1***.

Table 6.3: Elevation-Area Relationship for Sirkari Bhyol-Rupsiabagar HEP Catchment

Elevation (m)	Area Above Elevation (Km^2)
2014.0	957.00
2286.0	955.09
2438.4	952.79
2590.8	950.12
2743.2	946.48
2895.6	942.41
3048.0	935.99
3200.4	925.86
3352.8	907.47

3505.2	883.80
3657.6	857.07
3810.0	823.36
3962.4	782.80
4114.8	734.54
4267.2	672.95
4419.6	603.04
4572.0	526.48
4724.4	448.05
4876.8	373.70
5029.2	306.58
5181.6	243.75
5334.0	187.58
5486.4	140.00
5638.8	100.33
5791.2	72.11
5943.6	49.00
6096.0	33.00
6248.4	22.00
6400.8	15.00
6553.2	8.82
6705.6	5.13
6858.0	1.67

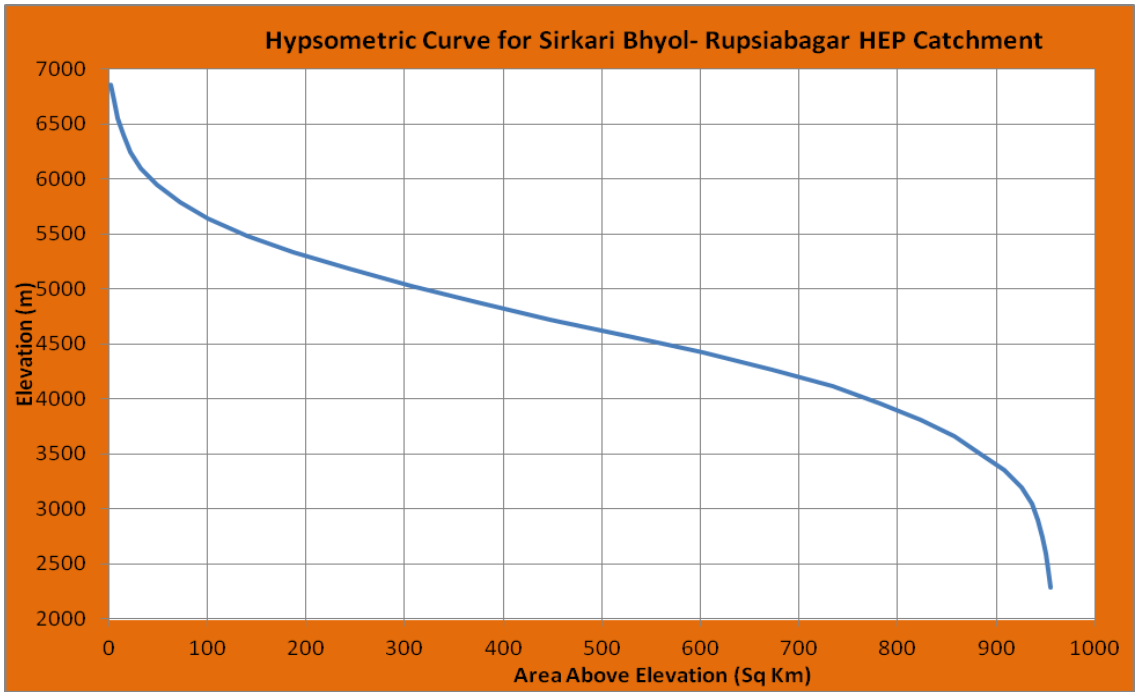


Figure 6.1: Plot of Hypsometric curve for Sirkari Bhyol-Rupsiabagar HEP Catchment

6.7. DATA AVAILABILITY

6.7.1. RAINFALL DATA

Several raingauge stations maintained by NHPC and other agencies in the Goriganga basin are available. The data availability is small with breaks. There are 6 raingauge stations whose data are available with varying periods. No SRRG data is available in the region. The details of ORRG station data availability is indicated in **Table 1.4** below:

Table 6.4: Rainfall Data Availability

S. No.	Station Name	Data availability	Altitude (m)	Data Type
1.	Dharchula	Jan. 1978 to Dec. 2004 with breaks	934	Monthly
2.	Tham	Mar. 1984 to Dec. 1988	777	Daily
3.	Madkot	Oct. 1987 to Jan. 1988	1285	Monthly
4.	Bangapani	Jul. 1986 to Dec. 1988	1010	Daily
5.	Devbagar	Jan. 1987 to Dec. 1990	-	Daily
6.	Jauljibi	Jan. 1977 to Dec. 1983	635	Daily

However due to scanty rainfall data availability with intermittently missing period and their location, it is not possible to utilize the same for assessment of catchment rainfall for G&D site as well as project site and consequently for assessment of water availability at the present.

6.7.2. DISCHARGE DATA

There exists 8 G&D stations in the region where discharges are available from CWC/ project authorities in the region. The nearest station with long term record is Jauljibi being maintained by CWC. Discharge data is also available at G&D sites maintained by NHPC on Goriganga river. Short term gauges are available at these sites during monsoon season. The details of 10-daily discharges available at various locations is indicated in **Table 1.5** below while the flows are at **Annexure I to VIII.** The locations of raingauge stations and G&D sites are indicated in **Plate-III.**

Table 6.5: Gauge and Discharge Data Availability

S. No.	Station Name	Name of River/ Tributary	Catchment area (sq km)	Data Type	Data Availability
1.	Rargiri	Goriganga	957	Daily	Oct 2010 to Jul 2012

2.	Madkot	Goriganga	1370	10-daily	Jun 1984 to Dec 1990
3.	Devbagar	Goriganga	1600	10-daily	Jun 1984 to Dec 1991 with breaks
4.	Bangapani	Goriganga	1908	10-daily	Aug 1976 to Dec 1988
5.	Tham	Goriganga	2223	10-daily	Aug 1976 to Dec 1988
6.	Jauljibi	Goriganga	2230	Daily	Aug 1976 to Dec 2009
7.	Tawaghat	Dhauliganga	1372	Daily	Nov 1976 to Oct 2005
8.	Paliakalan	Sarda	17676	Daily	Jun 1976 to Dec 2009

Site specific discharge observations are available at Rargiri from October 2010 till July 2012 (indicated above).

6.8. CONSISTENCY CHECK

Before adoption of observed discharge data, it is necessary to examine the same for their consistency and reliability. Both traditional subjective methods e.g., mass curve and double mass curve analysis along with objective methods like statistical methods have been used. The analysis on consistency and reliability checks have been carried out on discharge data of G&D sites namely Madkot, Bangapani, Tham, Jauljibi, Tawaghat etc. The details are as under:

6.8.1. RAINFALL DATA

As indicated in earlier para, there exist 6 rain gauge stations in the region where scanty rainfall data is available. The mean annual rainfall of these stations are given below in **Table 1.6**:

Table 6.6: Mean Annual Rainfall at Raingauge stations in Region

S. No.	Station name	Data period (years)	Mean annual rainfall (mm)
1.	Dharchula	27	2239
2.	Tham	5	2312
3.	Madkot	< 1	-
4.	Bangapani	2	1833
5.	Devbagar	4	2007
6.	Jauljibi	7	2618

A perusal of **Table 1.4** and **1.6** indicates that generally the rainfall data is available for very limited period (historical) at all raingauge stations except at Dharchula. Moreover Dharchula raingauge station is located outside the Goriganga catchment. Further most of the rainfall data pertains to three decade back period. It appears that the observations were discontinued subsequently at these stations. However an average (arithmetic) of the available rainfall data reveals an annual catchment rainfall of 2202 mm in the region upto Jauljibi.

6.8.2. RUNOFF DATA

i. 10-Daily Flow Pattern

It has been indicated in earlier paras that runoff data is available at several places in the Sarda basin for varying periods. Observed 10-daily flows of G&D stations namely Madkot, Bangapani, Tham, Jauljibi, and Tawaghat have been plotted to observe the flow pattern and trend at these sites. The plot reveals isolated peaks during monsoon period which do not match. But the general flows during monsoon and non-monsoon period are same. The 10-daily flow plots are shown in ***Fig 1.2 to 1.6***.

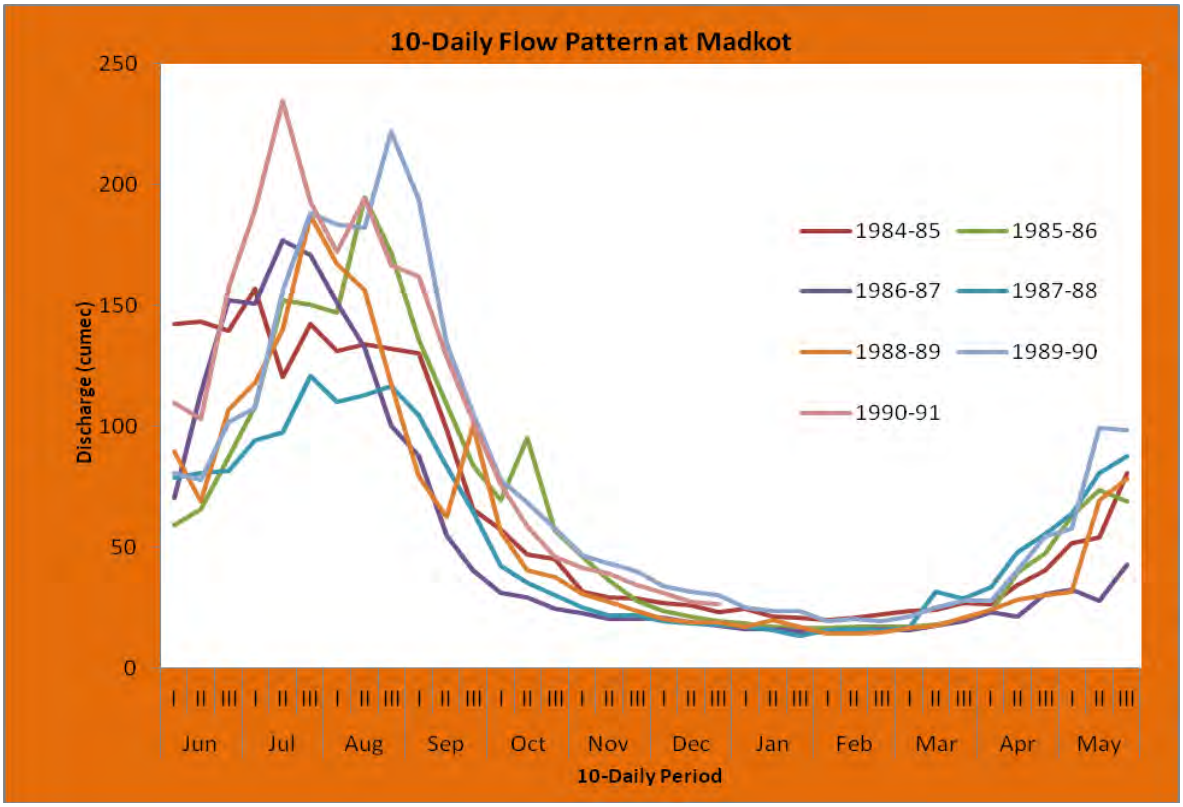


Figure 6.2: 10-daily flow pattern at Madkot

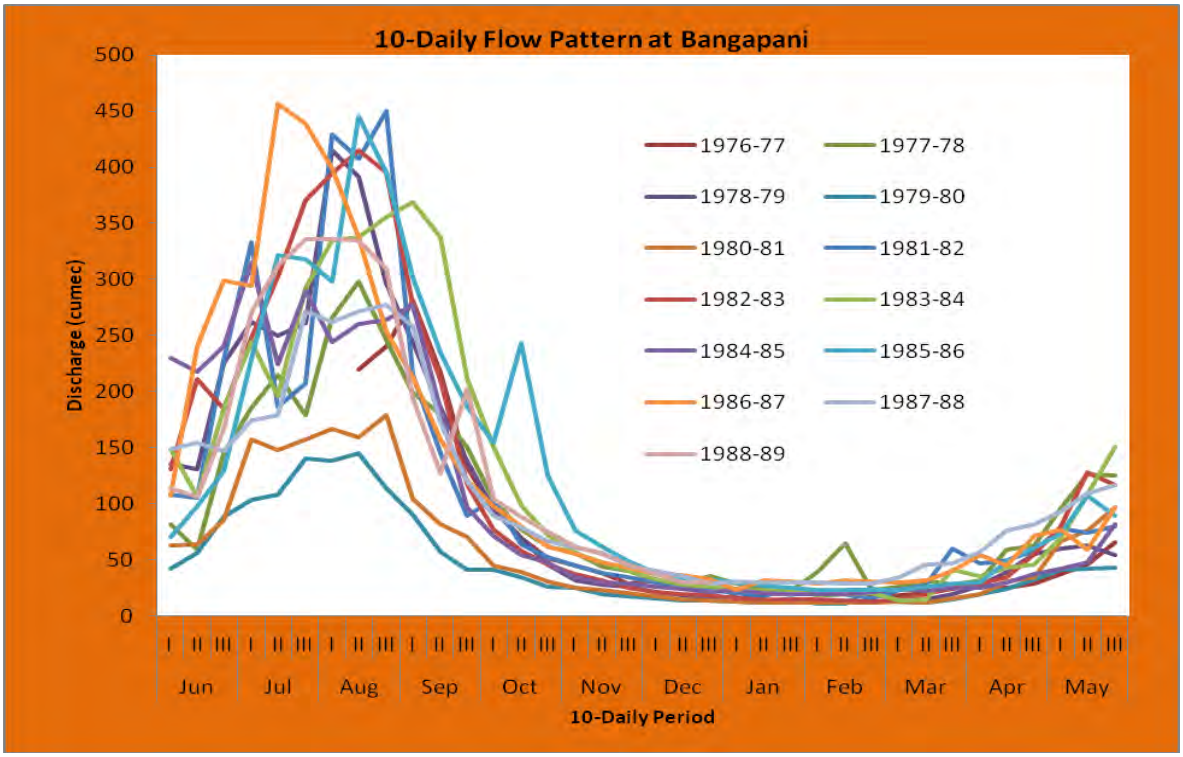


Figure 6.3: 10-daily flow pattern at Bangapani

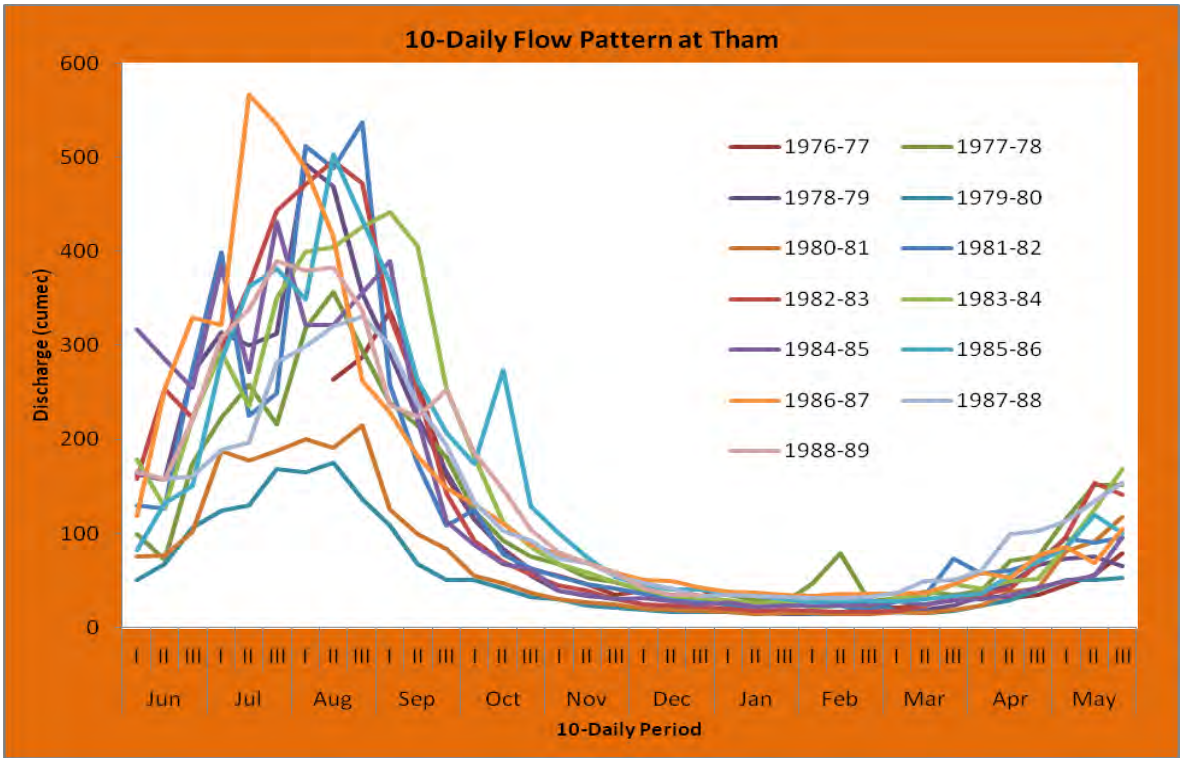


Figure 6.4: 10-daily flow pattern at Tham

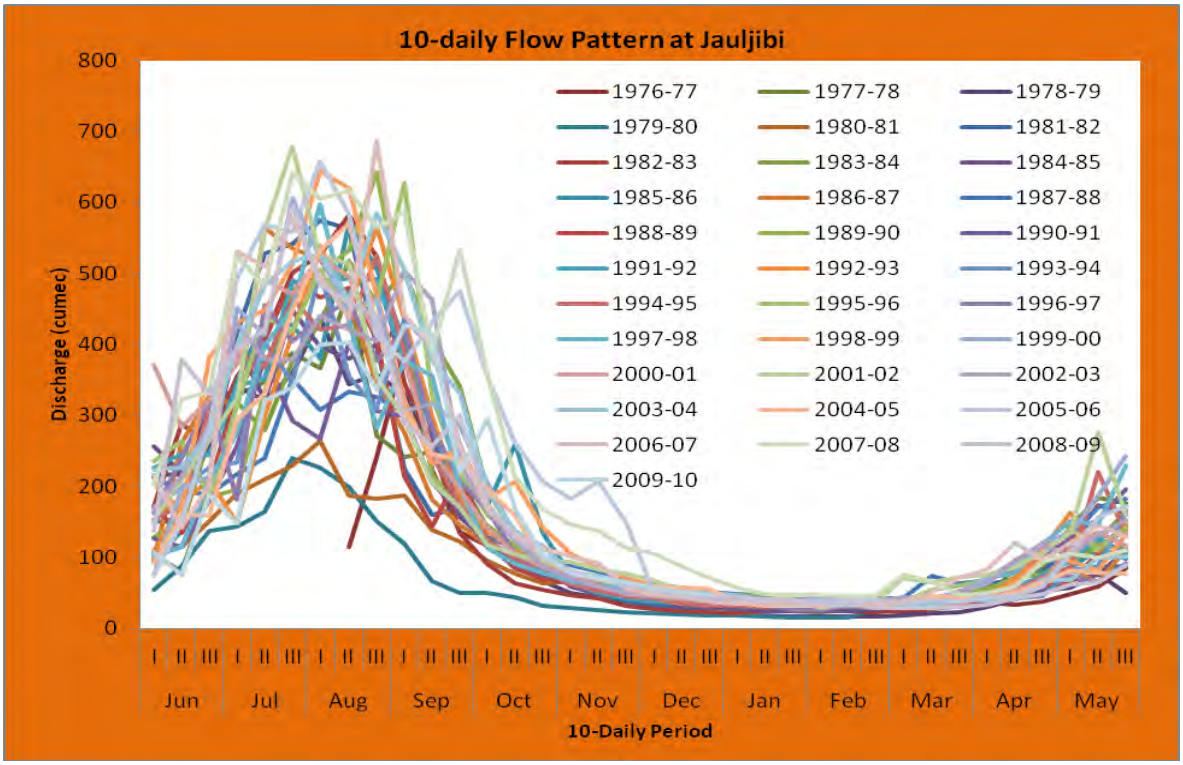


Figure 6.5: 10-daily flow pattern at Jauljibi

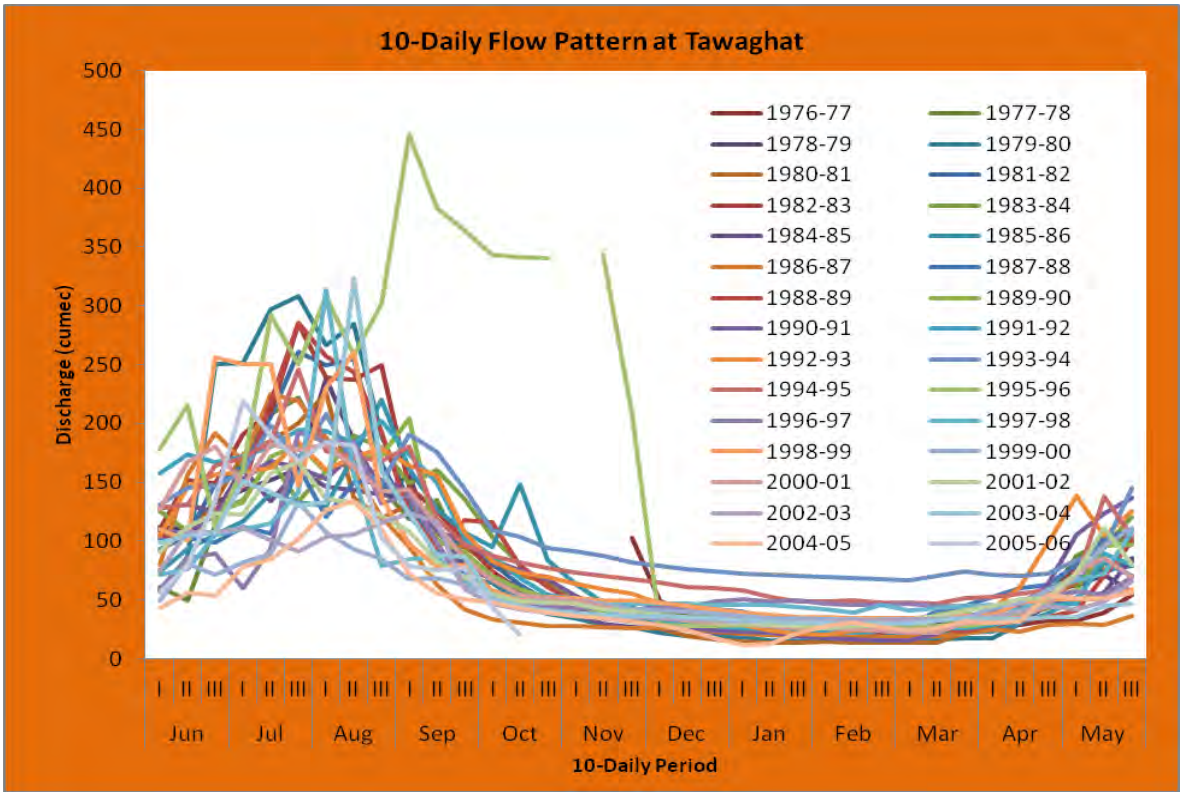


Figure 6.6: 10-daily flow pattern at Tawaghat

ii. Moving Average Method

Moving average analysis have been carried out for the observed discharge series of Madkot, Bangapani, Tham, Jauljibi and Tawaghat sites to assess the long term variability trend. The 5 years, 10 years and 15 years moving averages plots are developed using the available data. The plots are shown in ***Fig 1.7 to 1.15***.

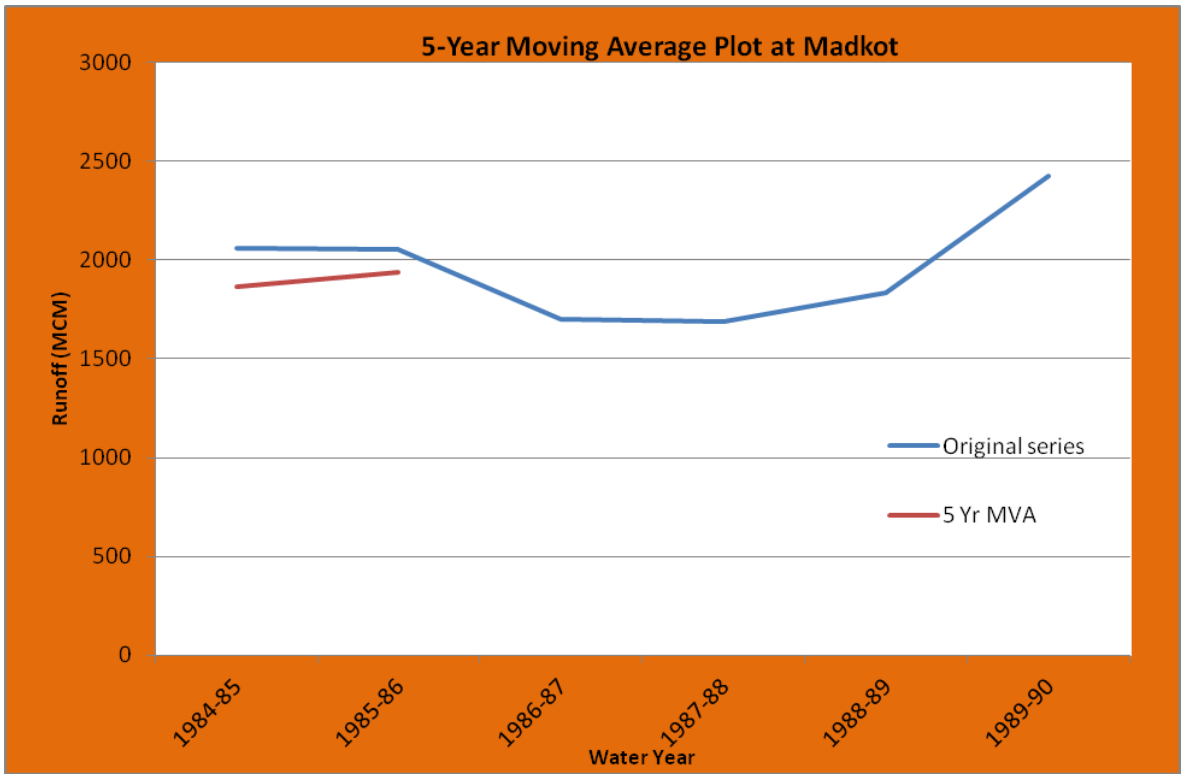


Figure 6.7: 5- Year Moving Average Plot of Runoff at Madkot

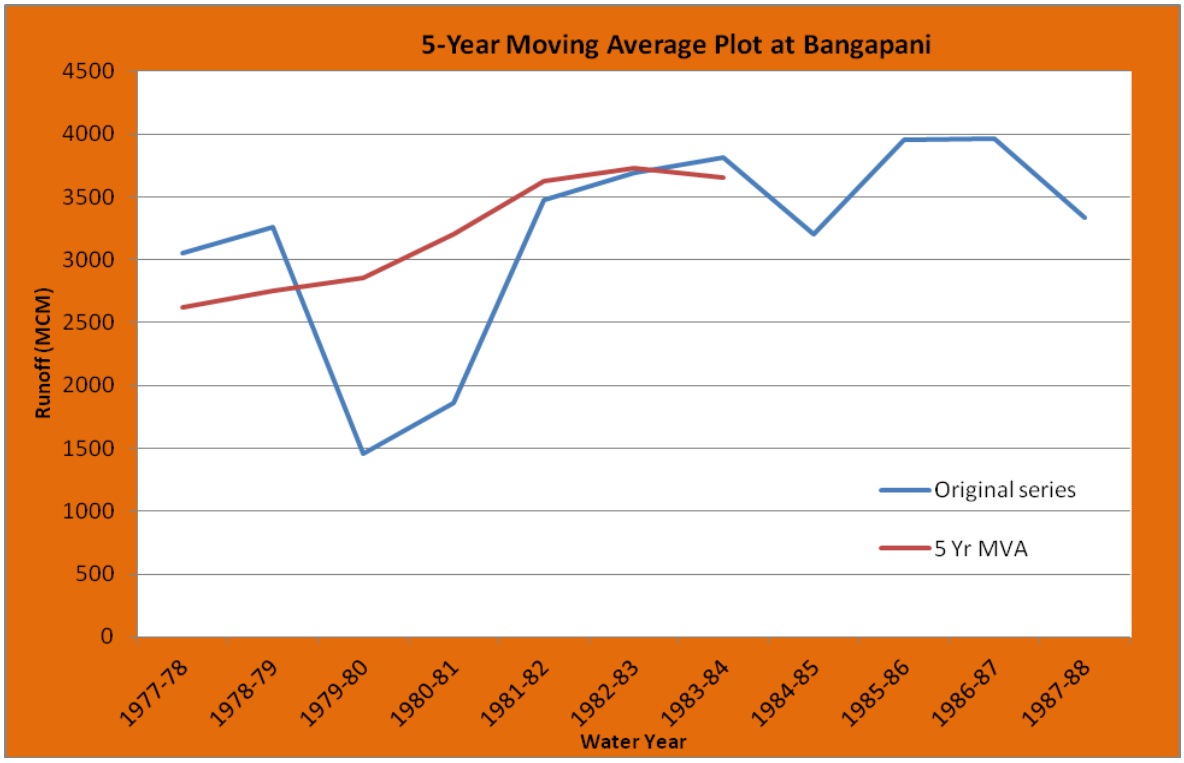


Figure 6.8: 5-Year Moving Average Plot of Runoff at Bangapani

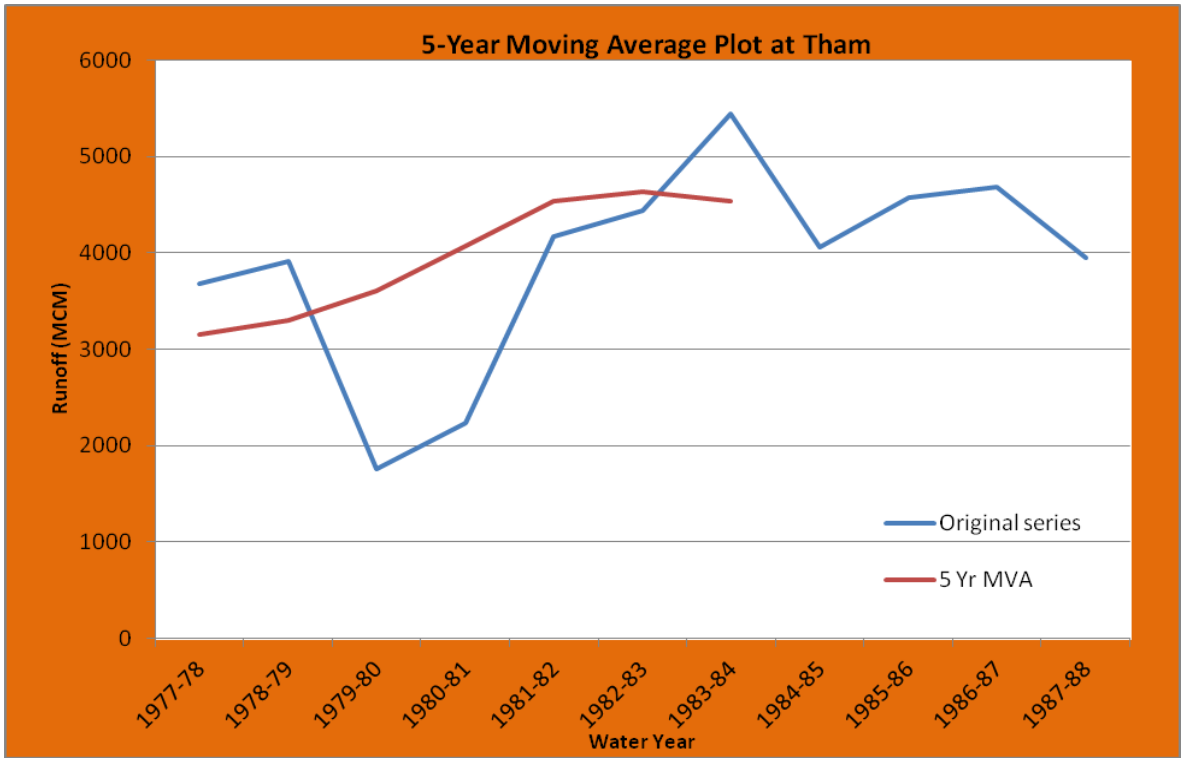


Figure 6.9: 5- Year Moving Average Plot of Runoff at Tham

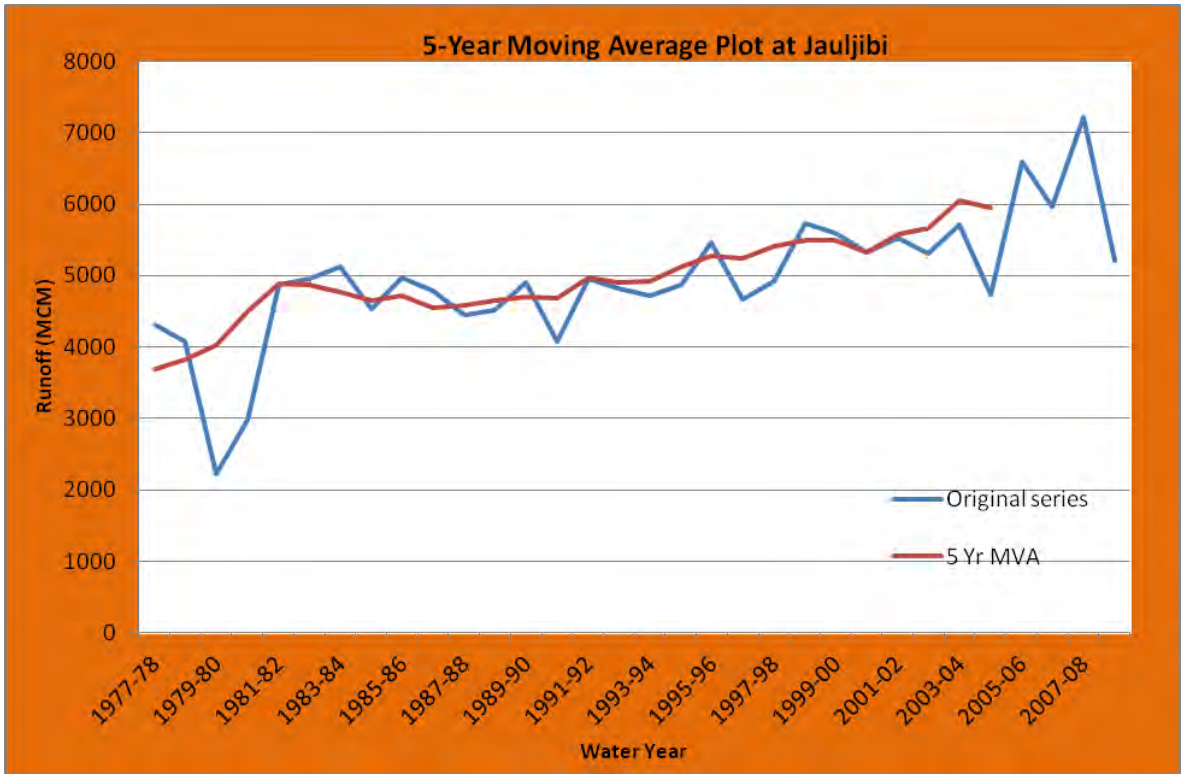


Figure 6.10: 5- Year Moving Average Plot of Runoff at Jauljibi

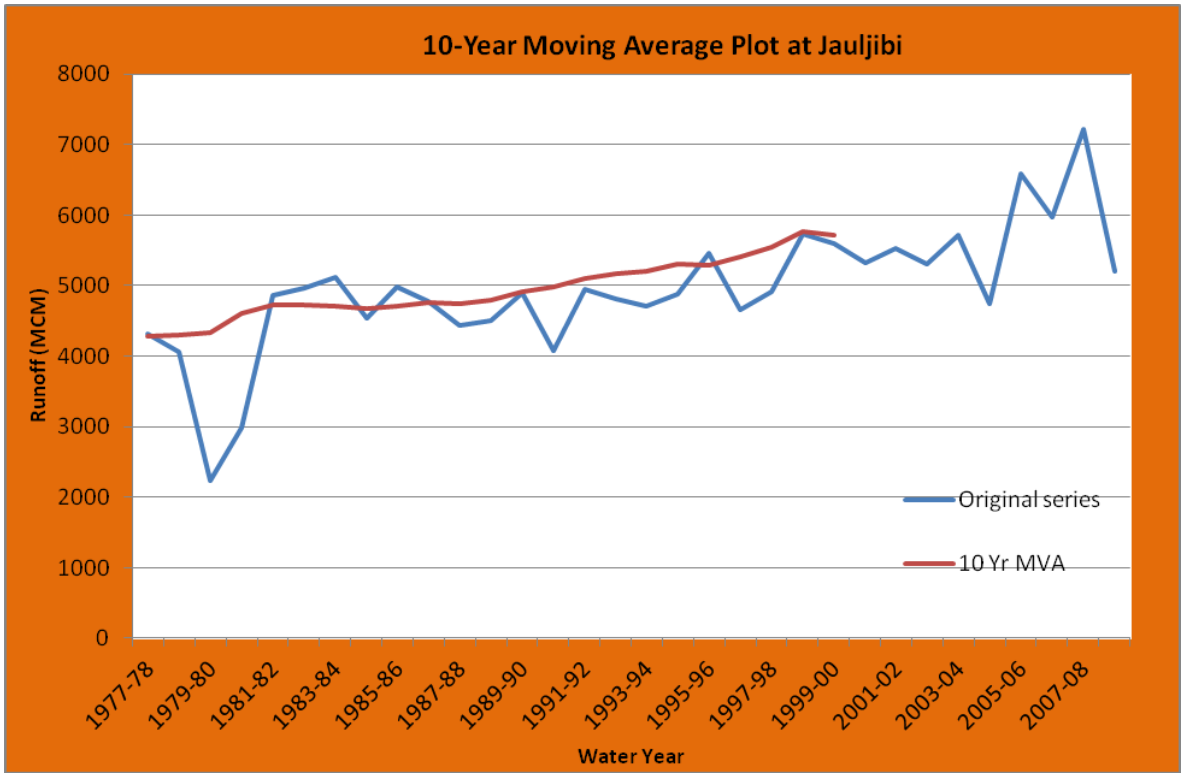


Figure 6.11: 10- Year Moving Average Plot of Runoff at Jauljibi

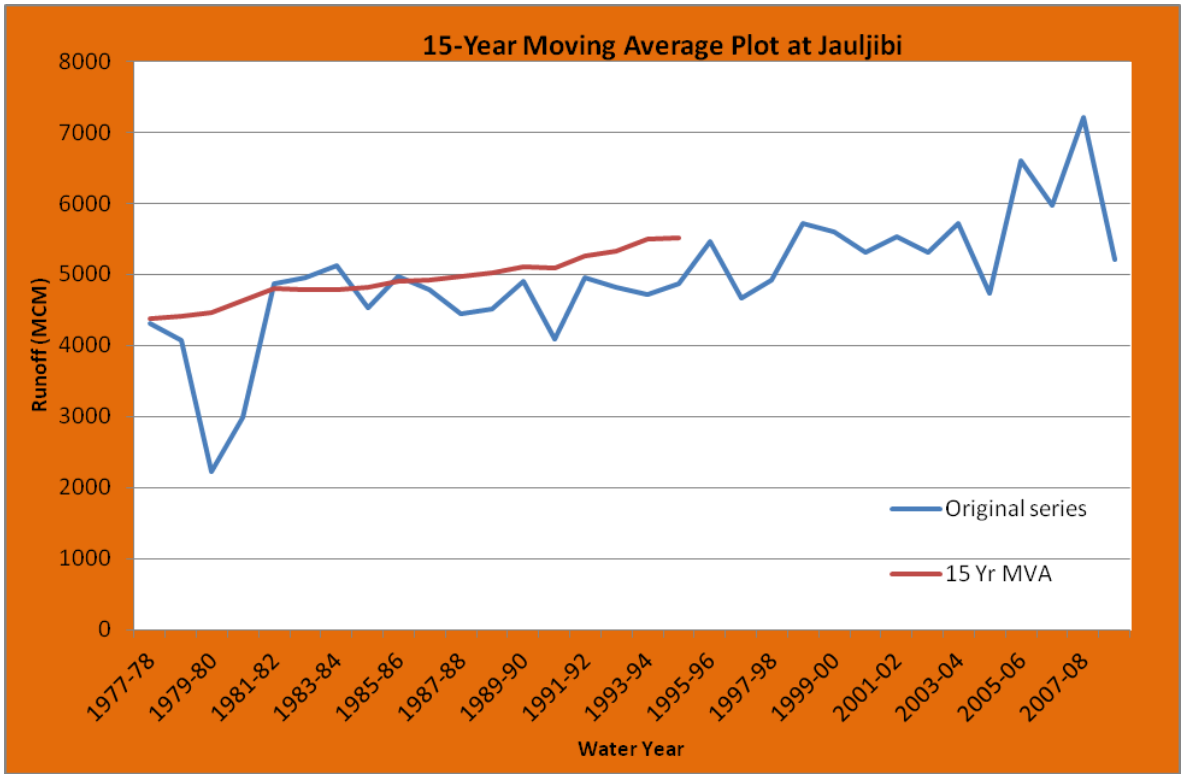


Figure 6.12: 15- Year Moving Average Plot of Runoff at Jauljibi

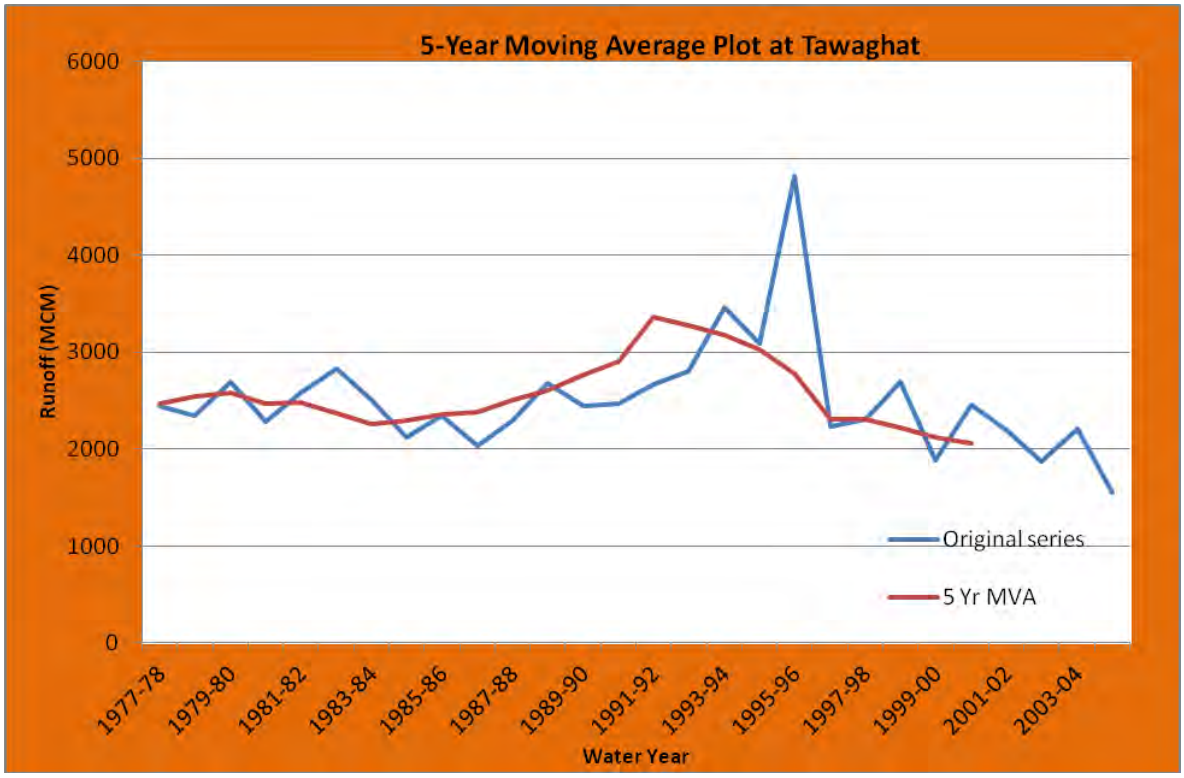


Figure 6.13: 5- Year Moving Average Plot of Runoff at Tawaghat

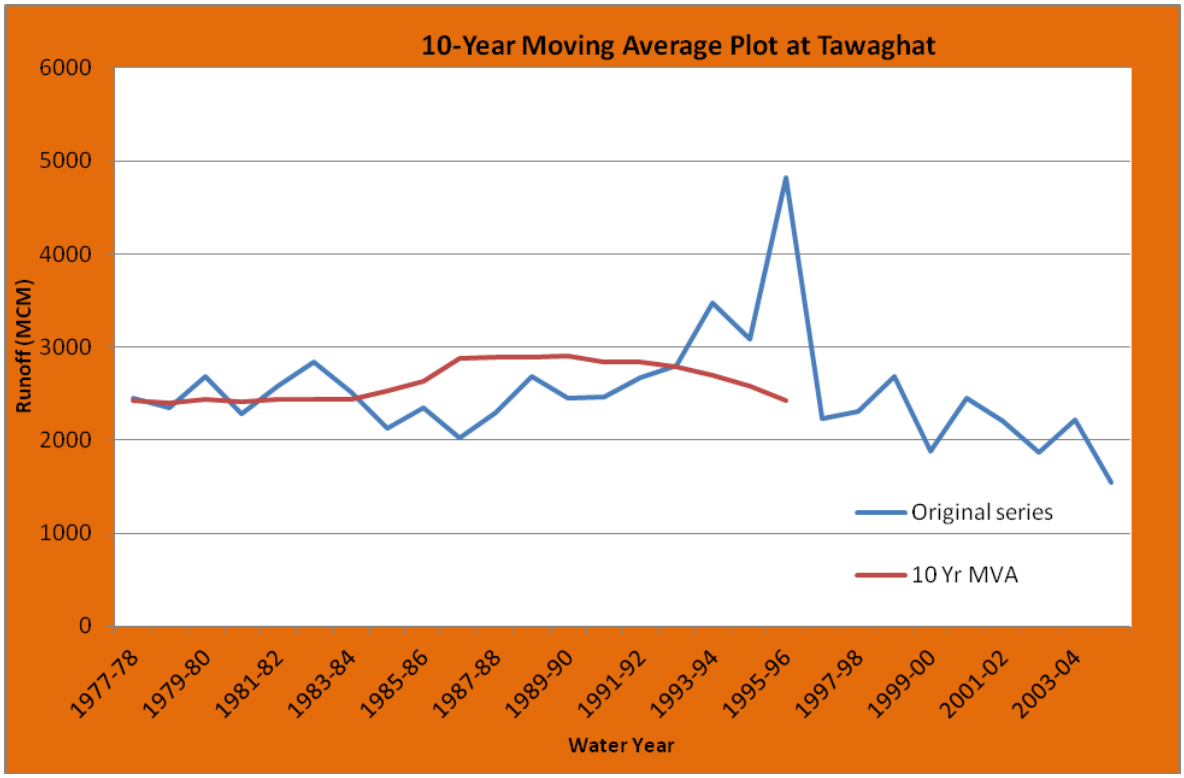


Figure 6.14: 10- Year Moving Average Plot of Runoff at Tawaghat

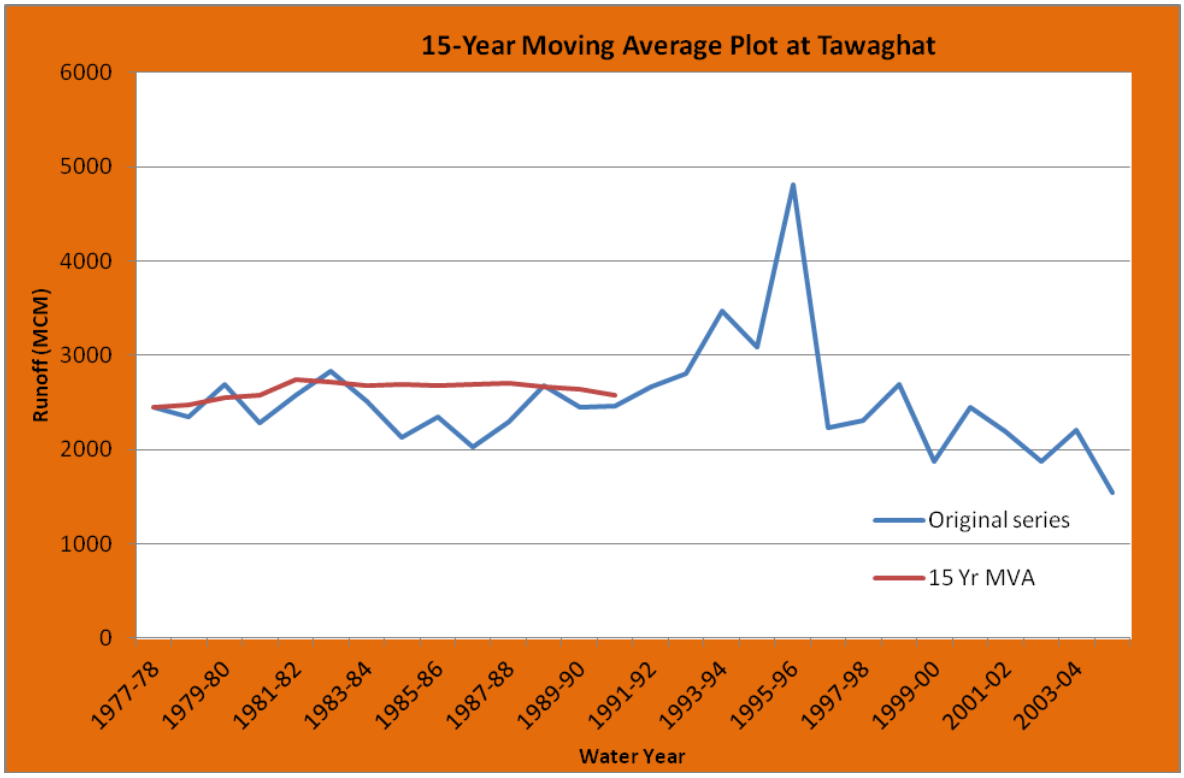


Figure 6.15: 15 Year Moving Average Plot of Runoff at Tawaghat

A perusal of the plots indicates that the annual pattern are identical. Further the 5 year and 10 year moving average line indicates rising trend at Bangapani, Tham and Jauljibi discharge sites in recent years. However Tawaghat site indicates a rising and then falling trend from 1995-96 onwards. This needs examination. Since the G&D site is located on Dhauliganga river an adjacent tributary of Kali river and not utilized in yield assessment, no examination (further) was carried out for this data except for assessing the data consistency and reliability of other G&D site data.

iii. Concurrent Average 10-Daily Flow

The concurrent period (1984-85 to 1987-88) of 10-daily average observed flows of Madkot, Bangapani, Tham, Jauljibi and Tawaghat were plotted to assess the data consistency. The plot reveals identical similar trends at all G & D stations. The plots are shown in ***Fig 1.16.***

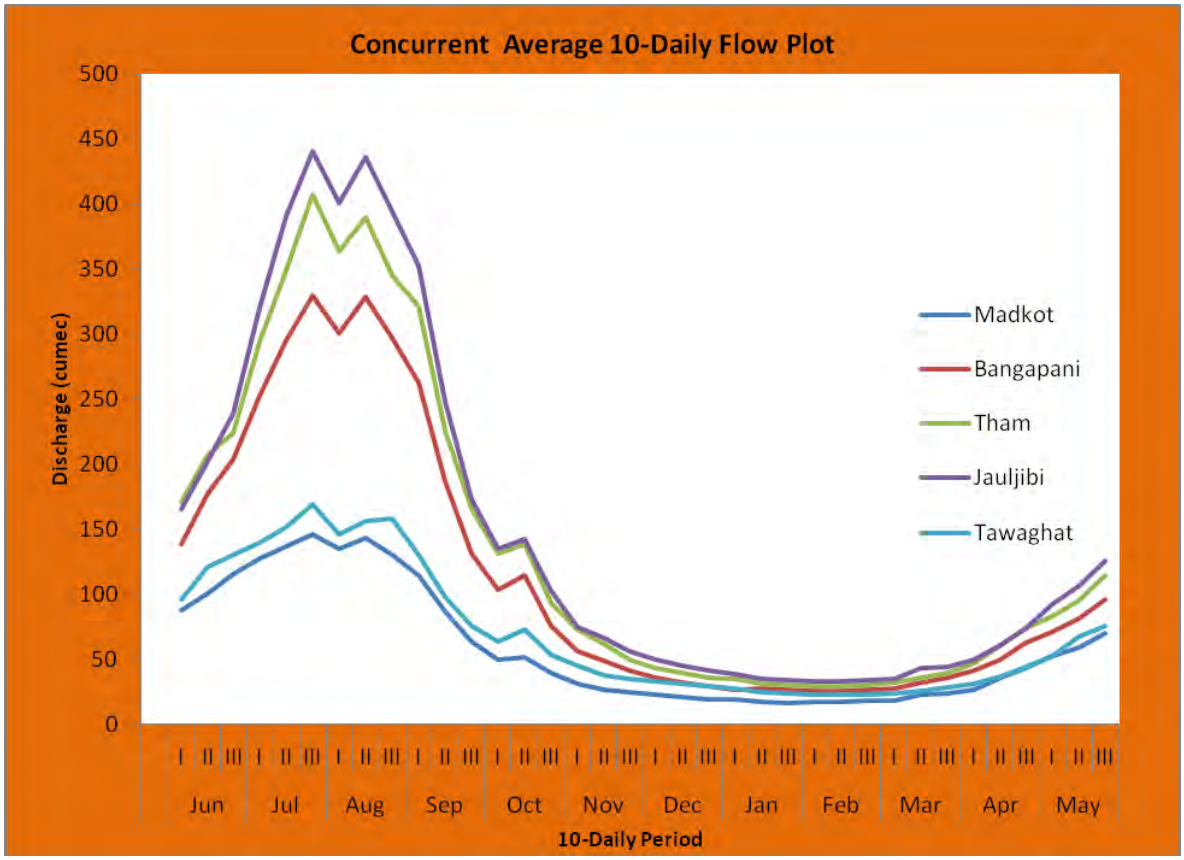


Figure 6.16: Concurrent Average 10-daily flow plot at various G & D stations

iv. Mass Curve

Mass curve have been drawn for Madkot, Bangapani, Tham, Jauljibi, and Tawaghat G&D sites utilizing the entire observed data. The same are available at ***Fig. 1.17 to 1.21*** which indicates that flows are consistent.

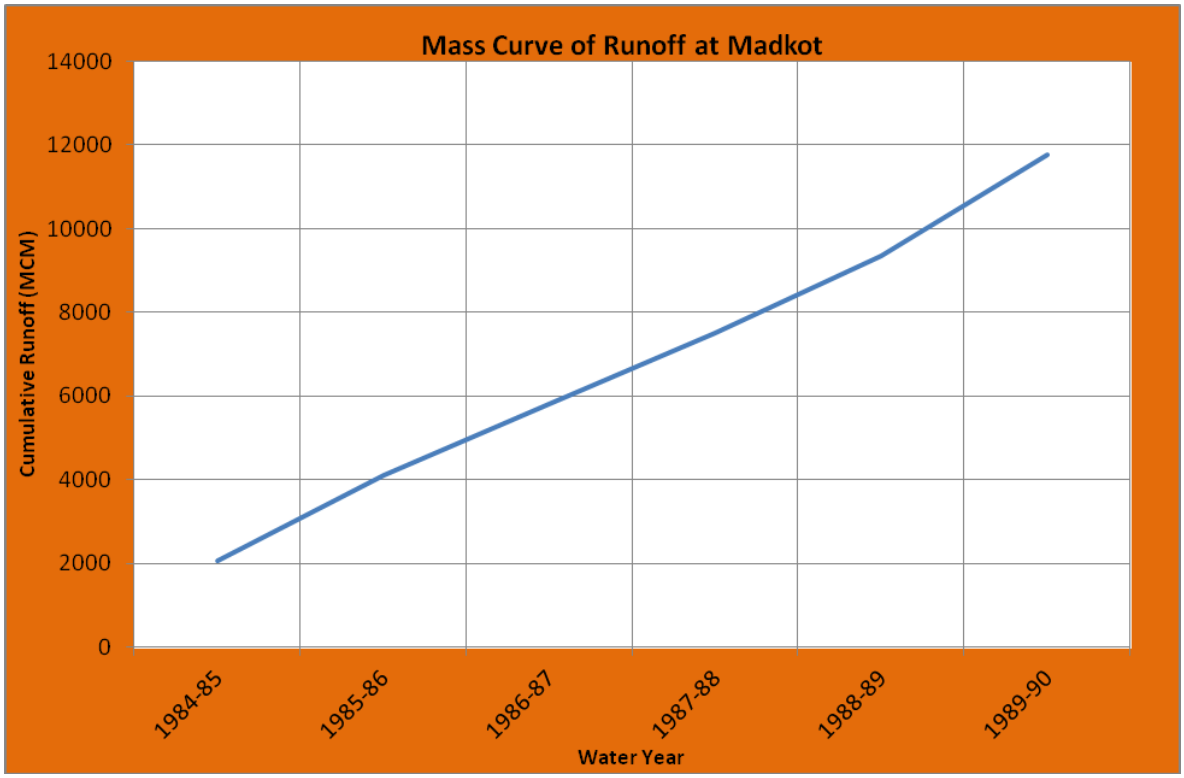


Figure 6.17: Mass curve (Madkot)

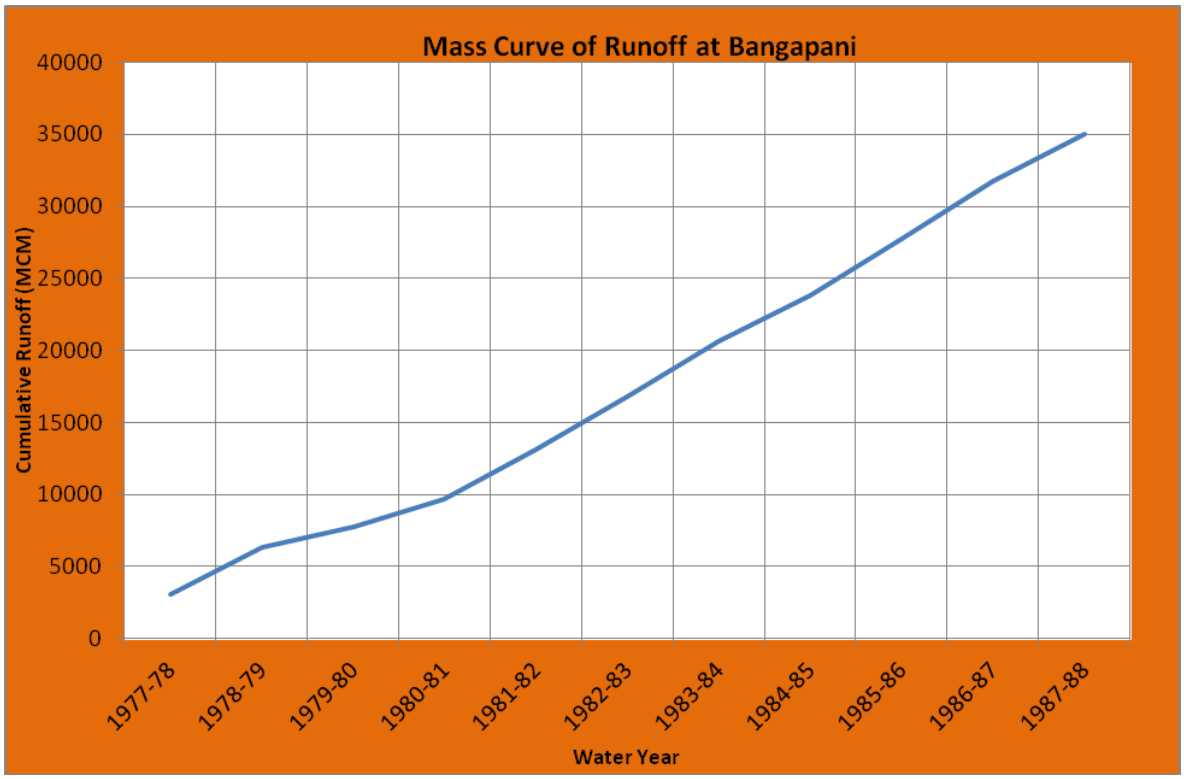


Figure 6.18: Mass curve (Bangapani)

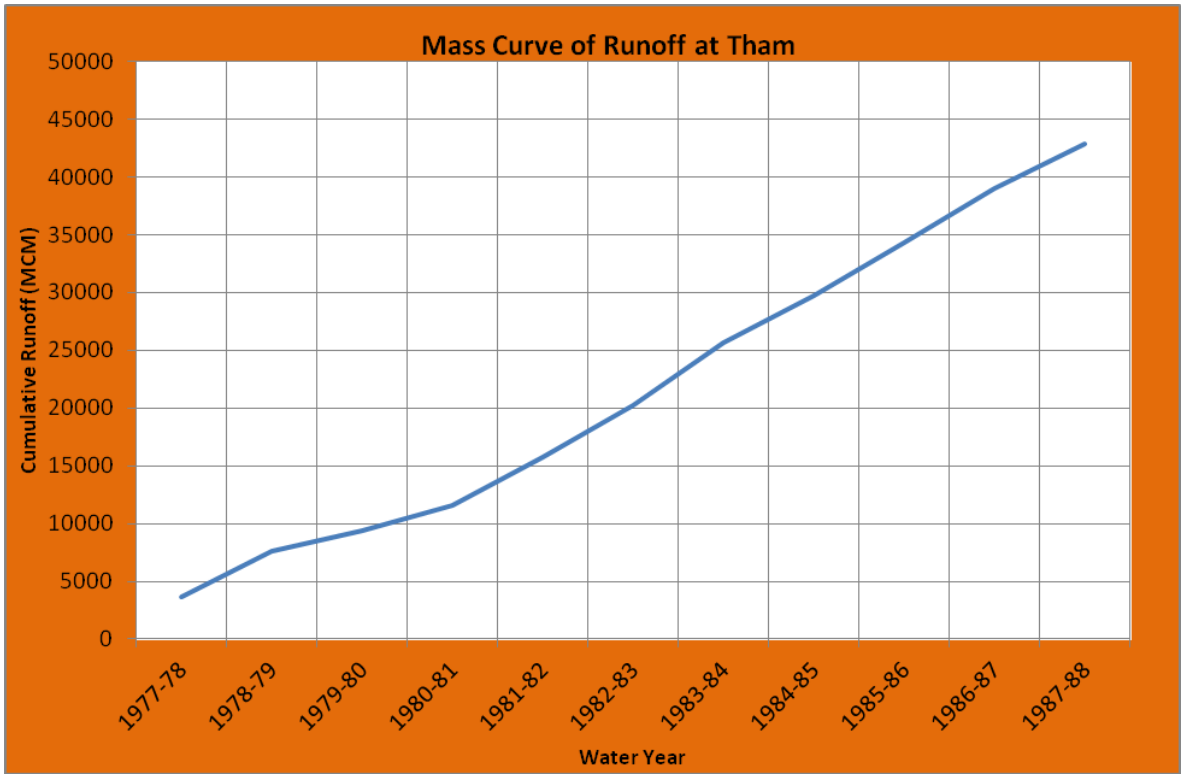


Figure 6.19: Mass curve (Tham)

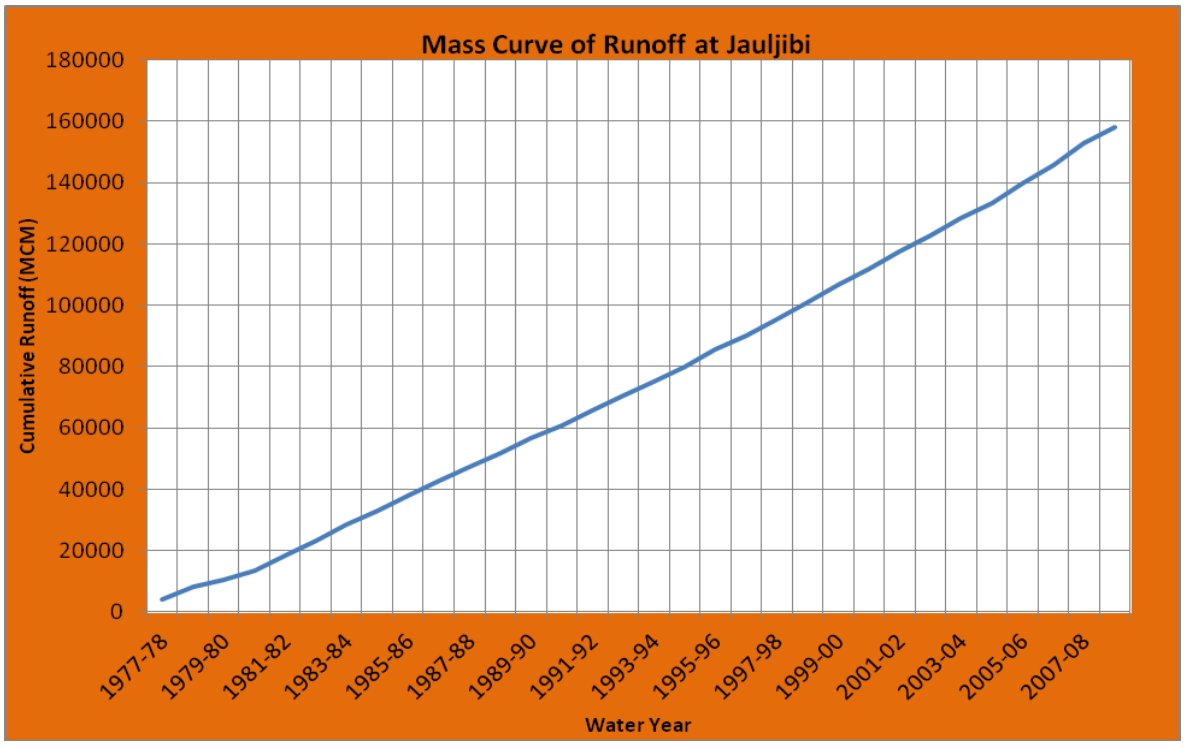


Figure 6.20: Mass curve (Jauljibi)

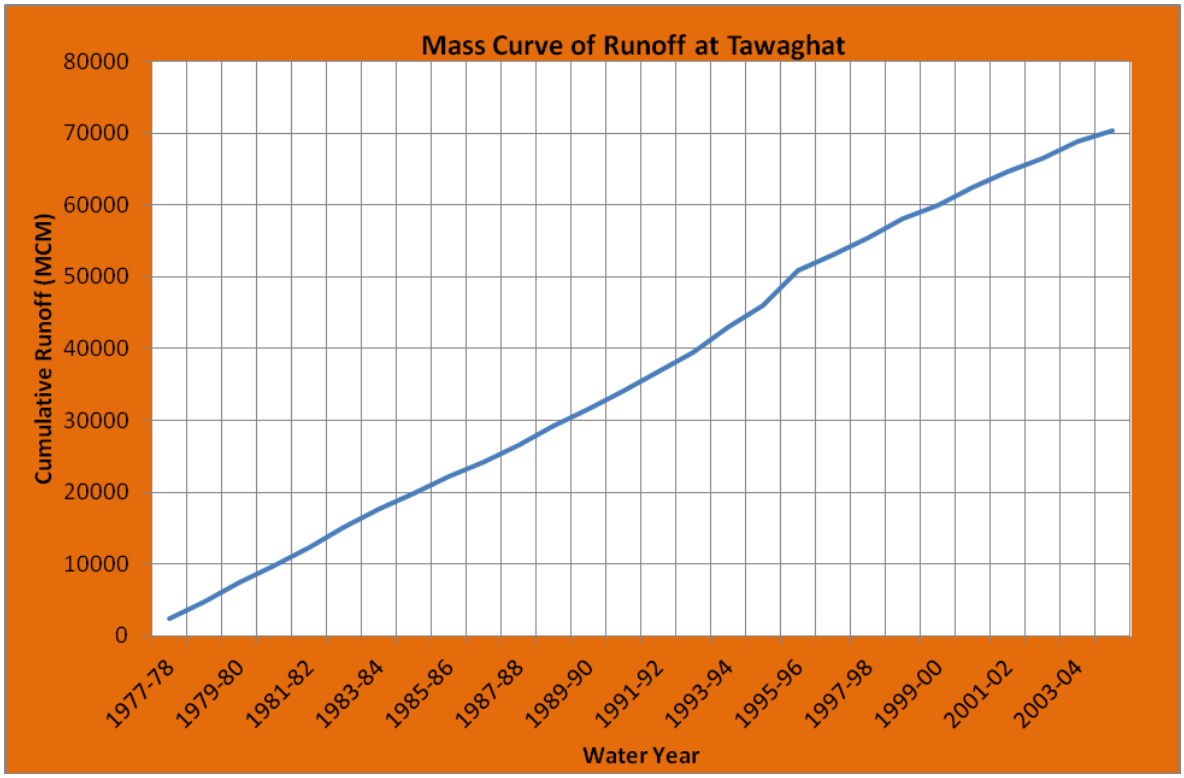


Figure 6.21: Mass curve (Tawaghat)

A perusal of the above figures indicates a kink in the mass curve during the year 1988-89 at Madkot. The mass curve at Bangapani indicates a kink in initial years of observations i.e., upto 1980-81, subsequently it indicates a straight line which implies that discharges observed in initial years appears to be on higher side. Tham site also indicates similarity with Bangapani site in observed discharges. The mass curve of Tawaghat G&D site indicates a kink during the year 1995-96. Similar discrepancy was observed in Tawaghat G&D site in the study carried out for moving average in earlier para.

v. Double Mass Curve

Similarly double mass curve between the observed discharges at Madkot, Bangapani, Tham, Jauljibi and Tawaghat sites were drawn which are available at ***Fig 1.22*** to 1***.31***.

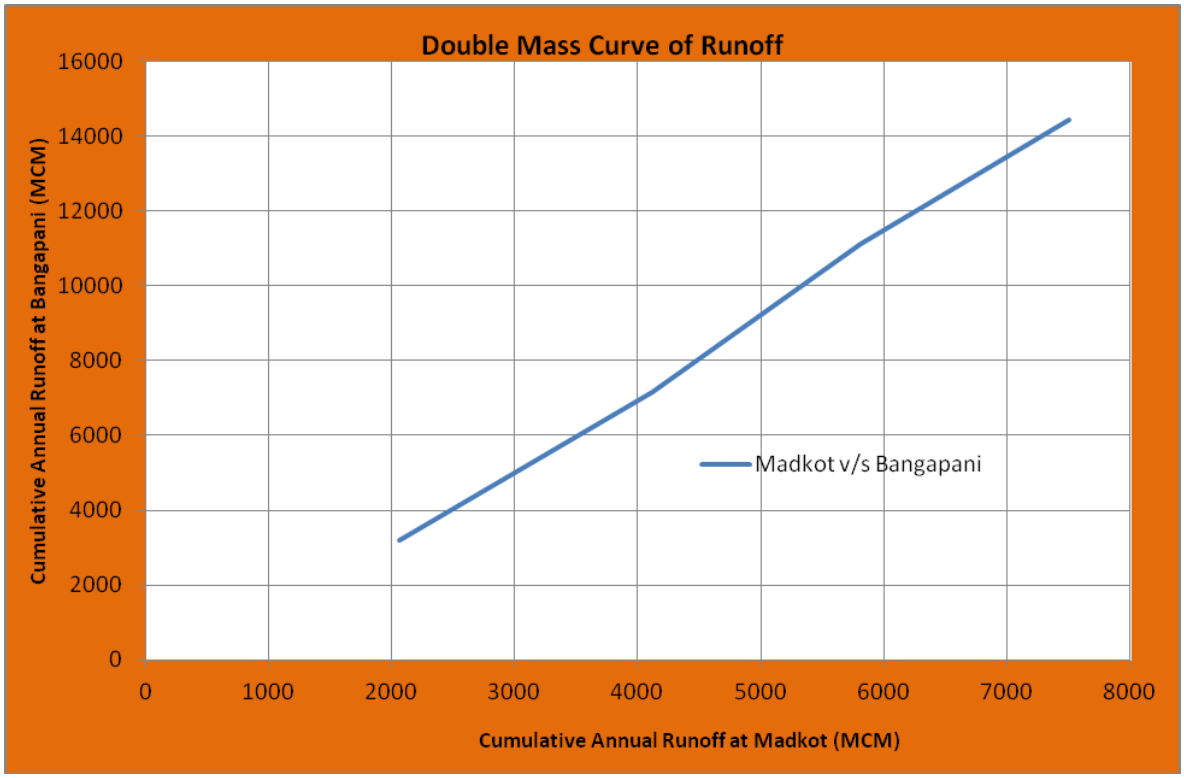


Figure 6.22: Double mass Curve between Madkot and Bangapani

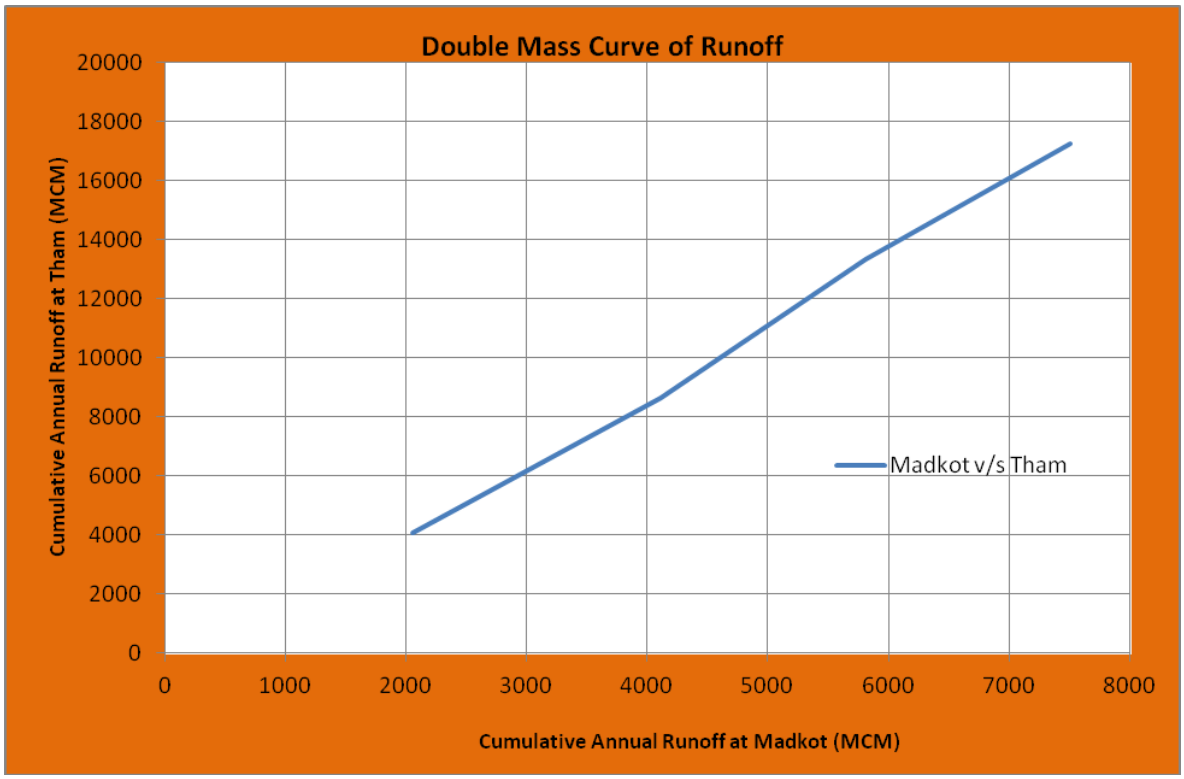


Figure 6.23: Double mass Curve between Madkot and Tham

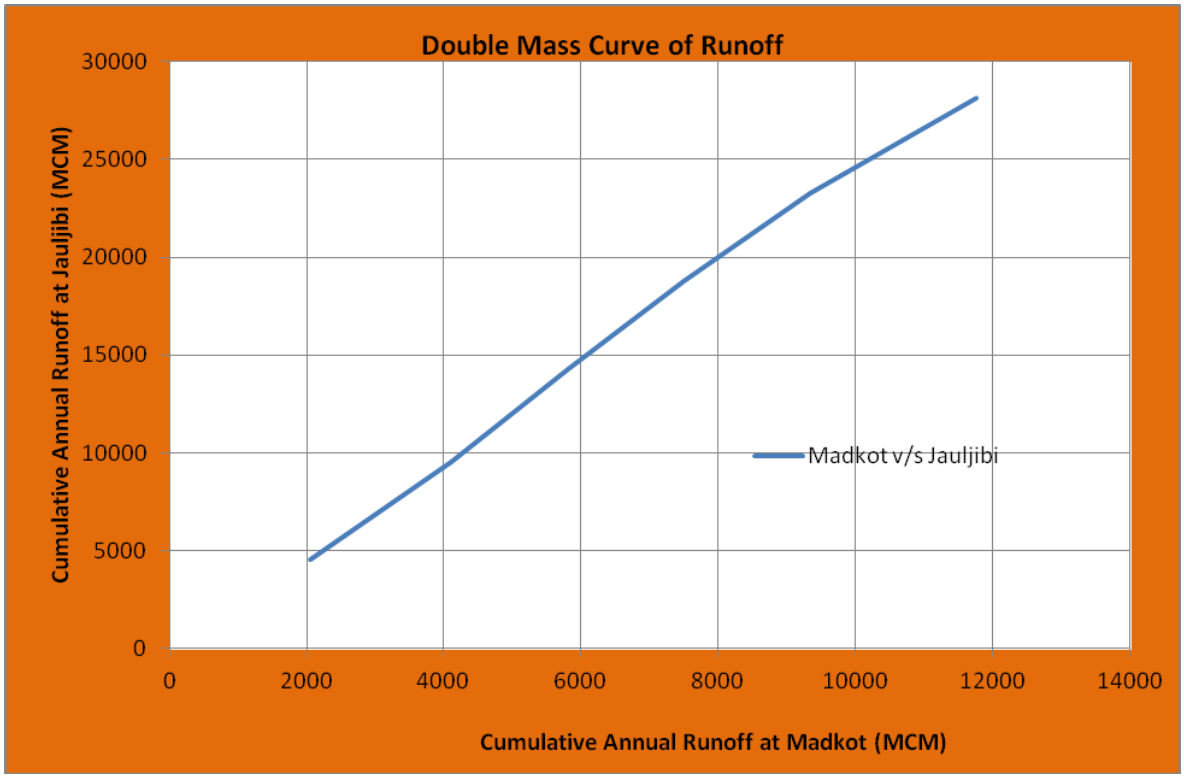


Figure 6.24: Double mass Curve between Madkot and Jauljibi

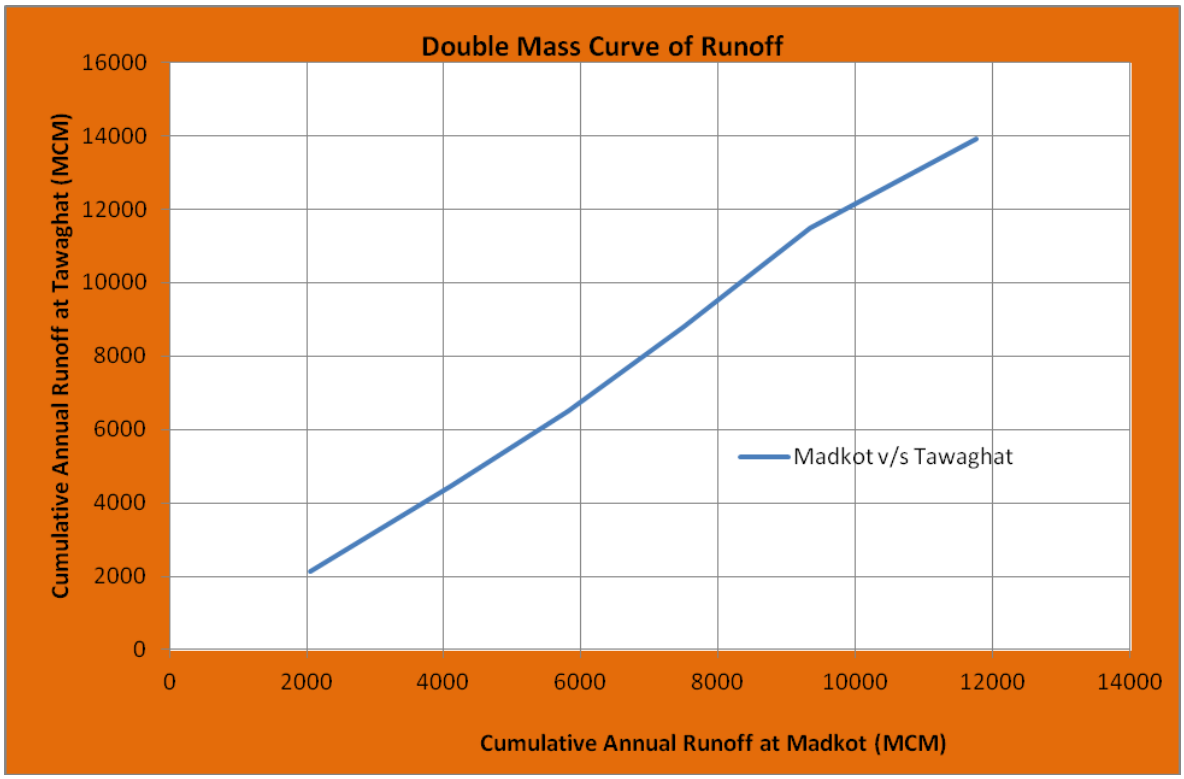


Figure 6.25: Double mass Curve between Madkot and Tawaghat

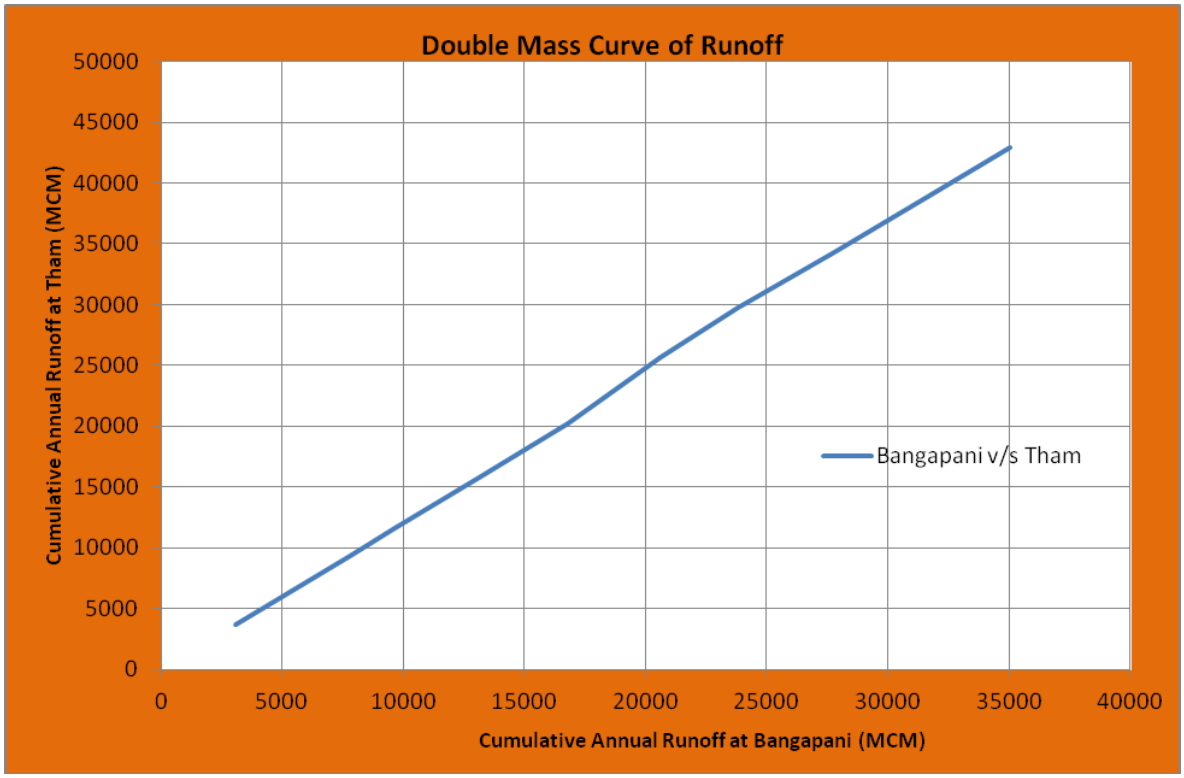


Figure 6.26: ***Double mass Curve between Bangapani and Tham***

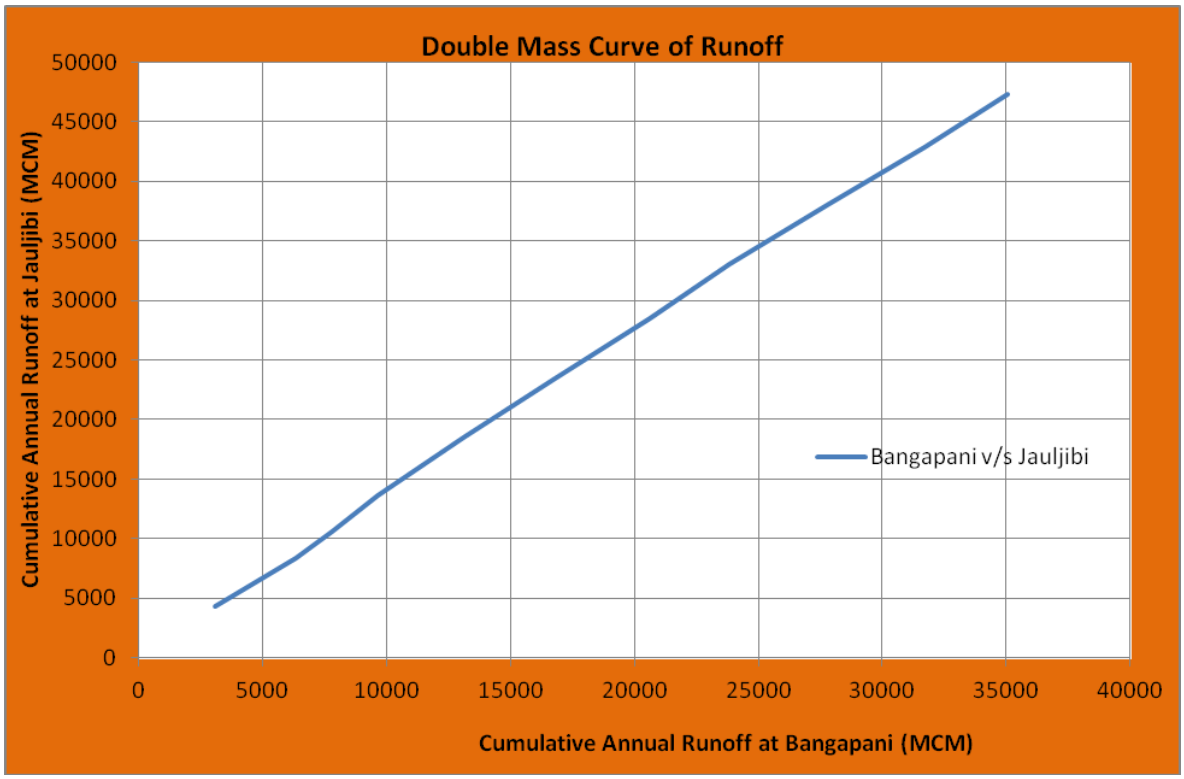


Figure 6.27: Double mass Curve between Bangapani and Jauljibi

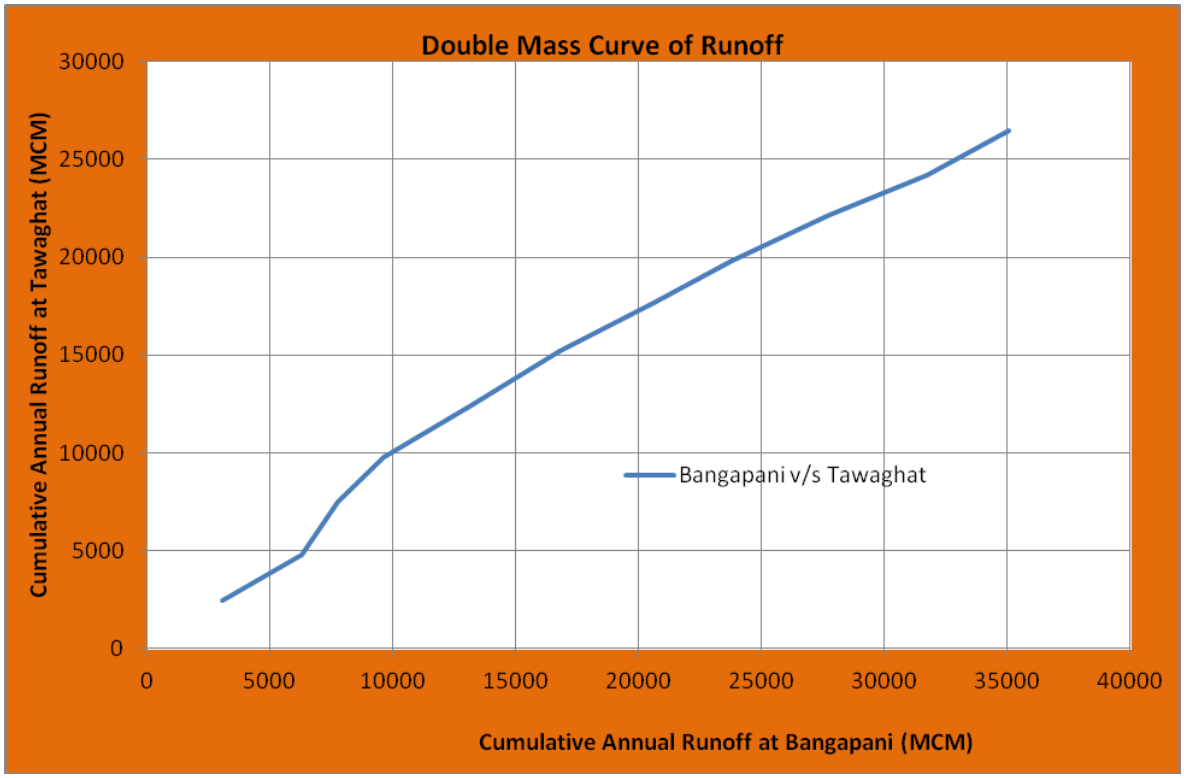


Figure 6.28: Double mass Curve between Bangapani and Tawaghat

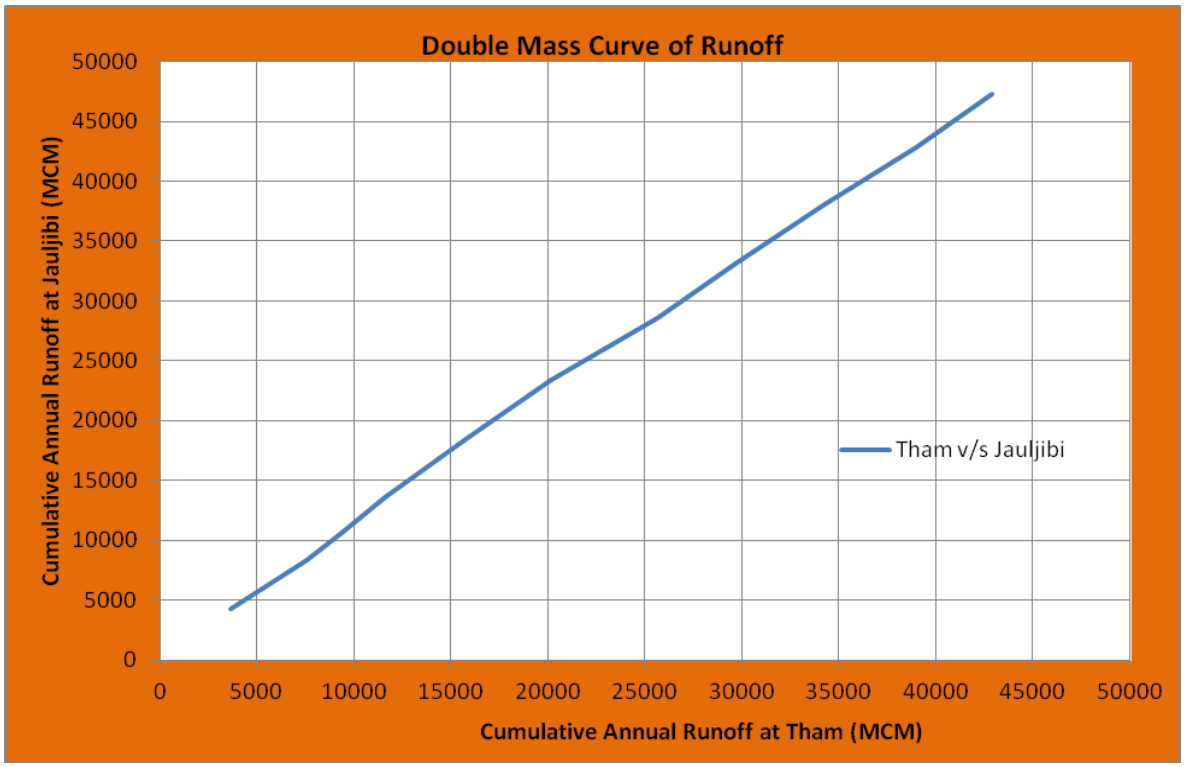


Figure 6.29: Double mass Curve between Tham and Jauljibi

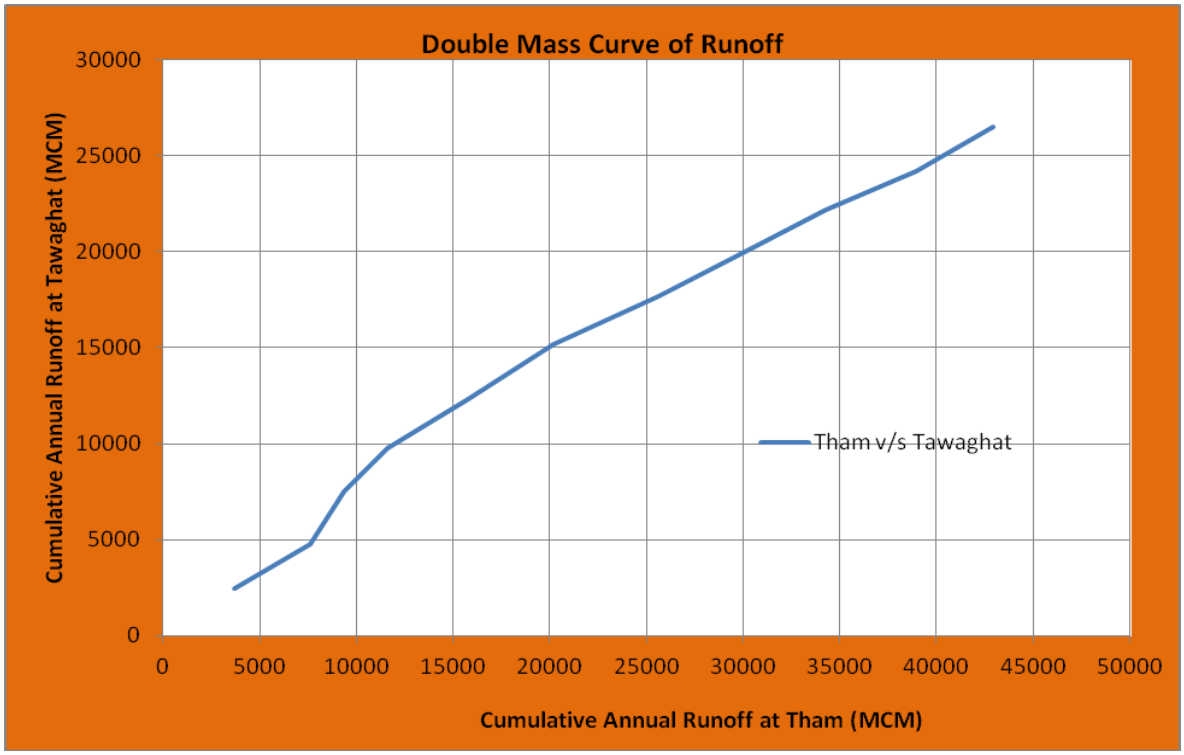


Figure 6.30: Double mass curve between Tham and Tawaghat

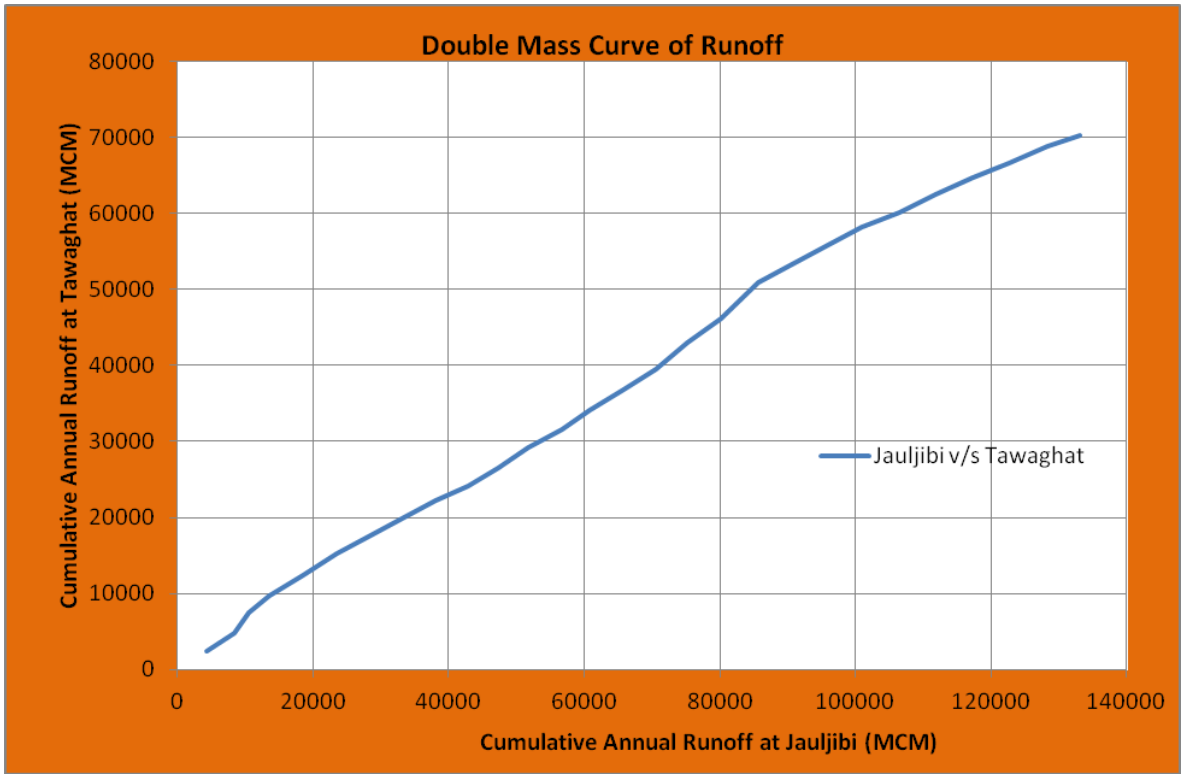


Figure 6.31: Double mass curve between Jauljibi and Tawaghat

A perusal of double mass curve indicates that Tawaghat discharges are not consistent with other G&D sites which may be due to the contribution of Dhauliganga river which may not show identical meteorological characteristics with Goriganga catchment. The double mass curve for G&D sites on Goriganga catchment appears to be reasonable and therefore can be utilized for yield assessment.

vi. Specific Yield

The annual specific yields at Madkot, Bangapani, Tham, Jauljibi, and Tawaghat sites for concurrent period (1984-85 to 1987-88) were compared to assess their reliability and consistency with details at ***Table 1.7***. An examination of the ***Table 1.7*** indicates that the annual specific yields at all the sites are identical and exhibit similar trend. This indicated that the observed data are identical and exhibit similar trends. However, it is noticed that the specific yield shows increasing trend with increasing catchment area thereby indicating higher rainfall at lower reaches.

Table 6.7: Specific Yield comparison of Various G&D sites for Concurrent period

Year	Madkot (CA-1370 Km2)	Bangapani (CA-1908 Km2)	Tham (CA-2223 Km2)	Jauljibi (CA-2230 Km2)	Tawaghat (CA-1372 Km2)
	(mm/year)	(mm/year)	(mm/year)	(mm/year)	(mm/year)
1984-85	1503.3	1678.5	1827.6	2034.3	1550.8
1985-86	1500.2	2072.1	2058.9	2232.8	1710.7
1986-87	1239.4	2075.0	2104.7	2144.4	1478.9
1987-88	1233.4	1745.7	1775.1	1992.7	1674.2
Average	1369.1	1892.8	1941.6	2101.0	1603.7

vii. Statistical Test

Homogeneity and statistical tests have been carried out by splitting the 10-daily observed discharge series of Madkot, Bangapani, Tham, Jauljibi and Tawaghat into two equal parts viz. (Variable 1) and (Variable 2). Statistical tests i.e. z-test, F-test and t-test have been carried out. It was noticed that most of these test results are found to be less than the critical values at 95% confidence level as detailed below:

A) Madkot

i) t-test- t test was also carried on the paired data whose results are as under

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	64.404	67.866
Variance	2481.546	3257.775
Observations	118	118

Pearson Correlation	-0.2615	
Hypothesized Mean Difference	0	
df	117	
t Stat	-0.4424	
P(T<=t) one-tail	0.3295	
t Critical one-tail	1.6580	
P(T<=t) two-tail	0.6590	
t Critical two-tail	1.9804	

ii) **z-test** - An easier method is to compute the standardized test statistic (z). The results of the computation are as under

z-Test: Two Sample for Means		
	Variable 1	*Variable 2*
Mean	64.404	67.866
Known Variance	2481.546	3257.775
Observations	118	118
Hypothesized Mean Difference	0	
z	-0.4964	
P(Z<=z) one-tail	0.3098	
z Critical one-tail	1.6449	
P(Z<=z) two-tail	0.6196	
z Critical two-tail	1.9600	

iii) **F-test** - An easier method is to compute the standardized test statistic (F). The results of the computation are as under

F-Test Two-Sample for Variances		
	Variable 1	*Variable 2*
Mean	64.404	67.866
Variance	2481.546	3257.775
Observations	118	118
df	117	117
F	0.7617	
P(F<=f) one-tail	0.0712	
F Critical one-tail	0.7368	

B) Bangapani

i) t-test- t test was also carried on the paired data whose results are as under

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	90.4978	111.3498
Variance	9827.557	11881.120
Observations	223	223
Pearson Correlation	0.0552	
Hypothesized Mean Difference	0	
df	222	
t Stat	-2.1740	
P(T<=t) one-tail	0.0154	
t Critical one-tail	1.6517	
P(T<=t) two-tail	0.0308	
t Critical two-tail	1.9707	

ii) z-test - An easier method is to compute the standardized test statistic (z). The results of the computation are as under

z-Test: Two Sample for Means		
	Variable 1	*Variable 2*
Mean	90.4978	111.3498
Known Variance	9827.557	11881.120
Observations	223	223
Hypothesized Mean Difference	0	
z	-2.1134	
P(Z<=z) one-tail	0.0173	
z Critical one-tail	1.6449	
P(Z<=z) two-tail	0.0346	
z Critical two-tail	1.9600	

iii) F-test - An easier method is to compute the standardized test statistic (F). The results of the computation are as under

F-Test Two-Sample for Variances		
	Variable 1	*Variable 2*
Mean	90.4978	111.3498
Variance	9827.557	11881.12
Observations	223	223
df	222	222
F	0.8272	
P(F<=f) one-tail	0.0791	
F Critical one-tail	0.8015	

C) Tham

i) t-test- t test was also carried on the paired data whose results are as under

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	108.7534	133.9148
Variance	14032.93	16796.53
Observations	223	223
Pearson Correlation	0.090778	
Hypothesized Mean Difference	0	
df	222	
t Stat	-2.2438	
P(T<=t) one-tail	0.0129	
t Critical one-tail	1.6517	
P(T<=t) two-tail	0.0258	
t Critical two-tail	1.9707	

ii) z-test - An easier method is to compute the standardized test statistic (z). The results of the computation are as under

z-Test: Two Sample for Means		
	Variable 1	*Variable 2*
Mean	108.7534	133.9148
Known Variance	14032.93	16796.53
Observations	223	223
Hypothesized Mean Difference	0	
z	-2.1400	
P(Z<=z) one-tail	0.0162	
z Critical one-tail	1.6449	
P(Z<=z) two-tail	0.0324	
z Critical two-tail	1.9600	

iii) F-test - An easier method is to compute the standardized test statistic (F). The results of the computation are as under

F-Test Two-Sample for Variances		
	Variable 1	*Variable 2*
Mean	108.7534	133.9148
Variance	14032.93	16796.53
Observations	223	223
df	222	222
F	0.8355	
P(F<=f) one-tail	0.0906	
F Critical one-tail	0.8015	

D) Jauljibi

i) t-test- t test was also carried on the paired data whose results are as under

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	135.87708	173.34678
Variance	19392.671	27487.684
Observations	601	601
Pearson Correlation	-0.3378	
Hypothesized Mean Difference	0	
df	600	
t Stat	-3.6750	
P(T<=t) one-tail	0.0001	
t Critical one-tail	1.6474	
P(T<=t) two-tail	0.0003	
t Critical two-tail	1.9639	

ii) z-test - An easier method is to compute the standardized test statistic (z). The results of the computation are as under

z-Test: Two Sample for Means		
	Variable 1	*Variable 2*
Mean	135.87708	173.34678
Known Variance	19392.671	27487.684
Observations	601	601
Hypothesized Mean Difference	0	
z	-4.2425	
P(Z<=z) one-tail	1.105E-05	
z Critical one-tail	1.6449	
P(Z<=z) two-tail	0.0000	
z Critical two-tail	1.9600	

iii) F-test - An easier method is to compute the standardized test statistic (F). The results of the computation are as under

F-Test Two-Sample for Variances		
	Variable 1	*Variable 2*
Mean	135.87708	173.34678
Variance	19392.671	27487.684
Observations	601	601
df	600	600
F	0.7055	
P(F<=f) one-tail	1.023E-05	
F Critical one-tail	0.8742	

E) Tawaghat

iv) t-test- t test was also carried on the paired data whose results are as under

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	74.9381	83.0569
Variance	3862.067	4329.766
Observations	520	520
Pearson Correlation	-0.4845	
Hypothesized Mean Difference	0	
df	519	
t Stat	-1.6793	
P(T<=t) one-tail	0.0469	
t Critical one-tail	1.6478	
P(T<=t) two-tail	0.0937	
t Critical two-tail	1.9645	

v) z-test - An easier method is to compute the standardized test statistic (z). The results of the computation are as under

z-Test: Two Sample for Means		
	Variable 1	*Variable 2*
Mean	74.9381	83.0569
Known Variance	3862.067	4329.766
Observations	520	520
Hypothesized Mean Difference	0	
z	-2.0455	
P(Z<=z) one-tail	0.0204	
z Critical one-tail	1.6449	
P(Z<=z) two-tail	0.0408	
z Critical two-tail	1.9600	

vi) F-test - An easier method is to compute the standardized test statistic (F). The results of the computation are as under

F-Test Two-Sample for Variances		
	Variable 1	*Variable 2*
Mean	74.9381	83.0569
Variance	3862.067	4329.766
Observations	520	520
df	519	519
F	0.8920	
P(F<=f) one-tail	0.0966	

F Critical one-tail	0.8654	

6.9. WATER AVAILABILITY STUDY

It has been indicated in earlier paras that the network of existing rain gauge stations are inadequate for assessing the catchment rainfall so as to develop a rainfall – runoff model. Even the rainfall data availability is meager and rainfall data is not available for recent period. As such, recourse was taken to utilize the runoff observed at various G&D sites for assessment of yield for the proposed HE Project utilizing the runoff-runoff model..

Stream flow records are available at six G&D sites viz. Madkot, Devbagar, Bangapani, Tham, Jauljibi and Tawaghat whose details are given in earlier paras and observed data is available at Annexure- II to VII. Further it has been indicated in earlier paras that the observed discharges at Tawaghat sites are not reliable, though consistent. The Madkot is the nearest G&D station to the proposed project site. The observed discharges at Madkot is consistent but is of smaller duration. As such the same needs to be extended by developing a runoff-runoff model for utilization in assessing the yield at proposed project site.

It has been indicated in earlier paras that Jauljibi (CA=2230 km^2) discharge data is available for the period August 1976 to December 2009. Since Madkot data is available for the period June 1984 to December 1990, it is proposed to utilise the same for development of a Runoff –Runoff model between the concurrent period of Jauljibi and Madkot for monsoon and non-monsoon period. In addition monthly correlations were also developed, but due to low correlation coefficients, the same were not considered in the present study and only seasonal model was utilized in the present study. The details of Runoff-Runoff model are as under:

1) Runoff –Runoff model between Jauljibi and Madkot

Length of data utilized June 1984 to December 1990

Monsoon Period (June - September)

Model Equation $Q_{(Madkot)} = 0.248 (Q_{Jauljibi}) + 46.236$

Correlation coefficient = 0.7191

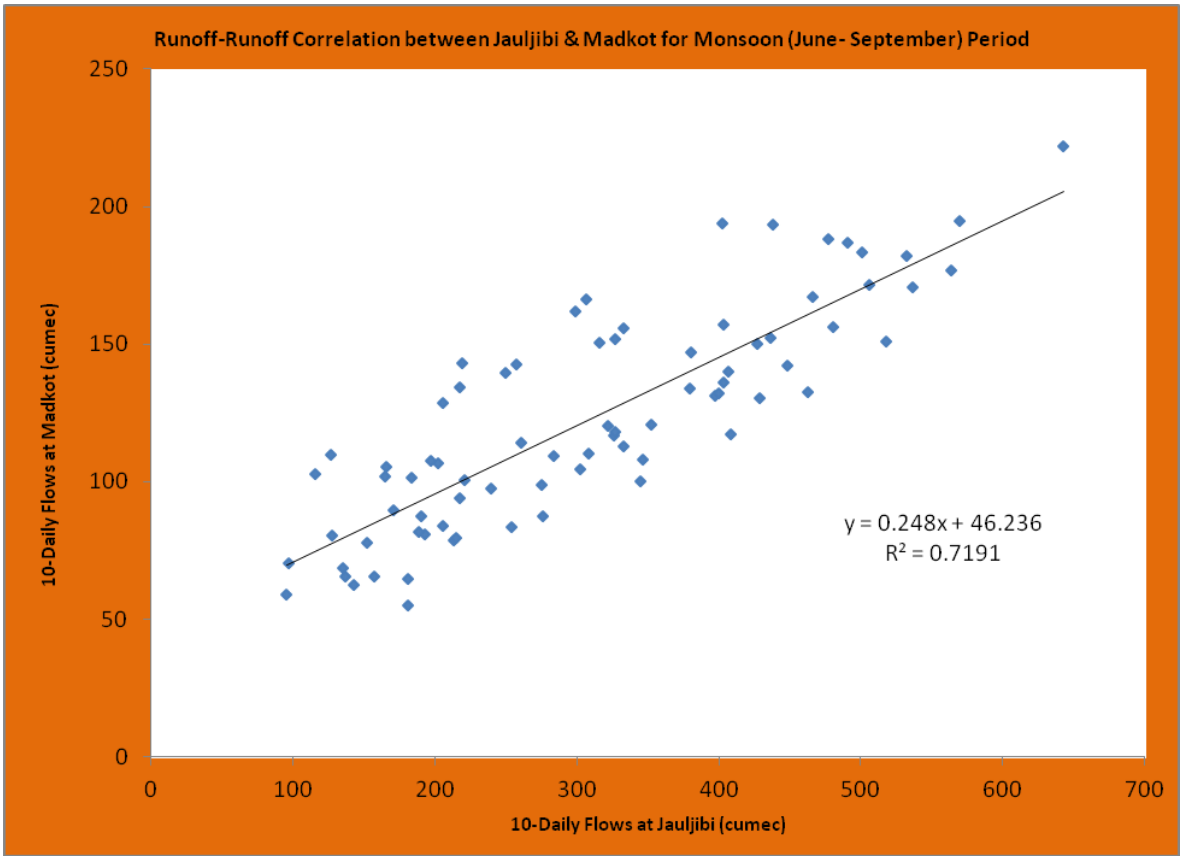


Figure 6.32: Runoff-Runoff correlation between Jauljibi & Madkot for Monsoon Period

Non-Monsoon Period (October – May)

Model Equation $Q_{(Madkot)} = 0.4239\ Q_{Jauljibi} + 5.267$

Correlation coefficient = 0.7514

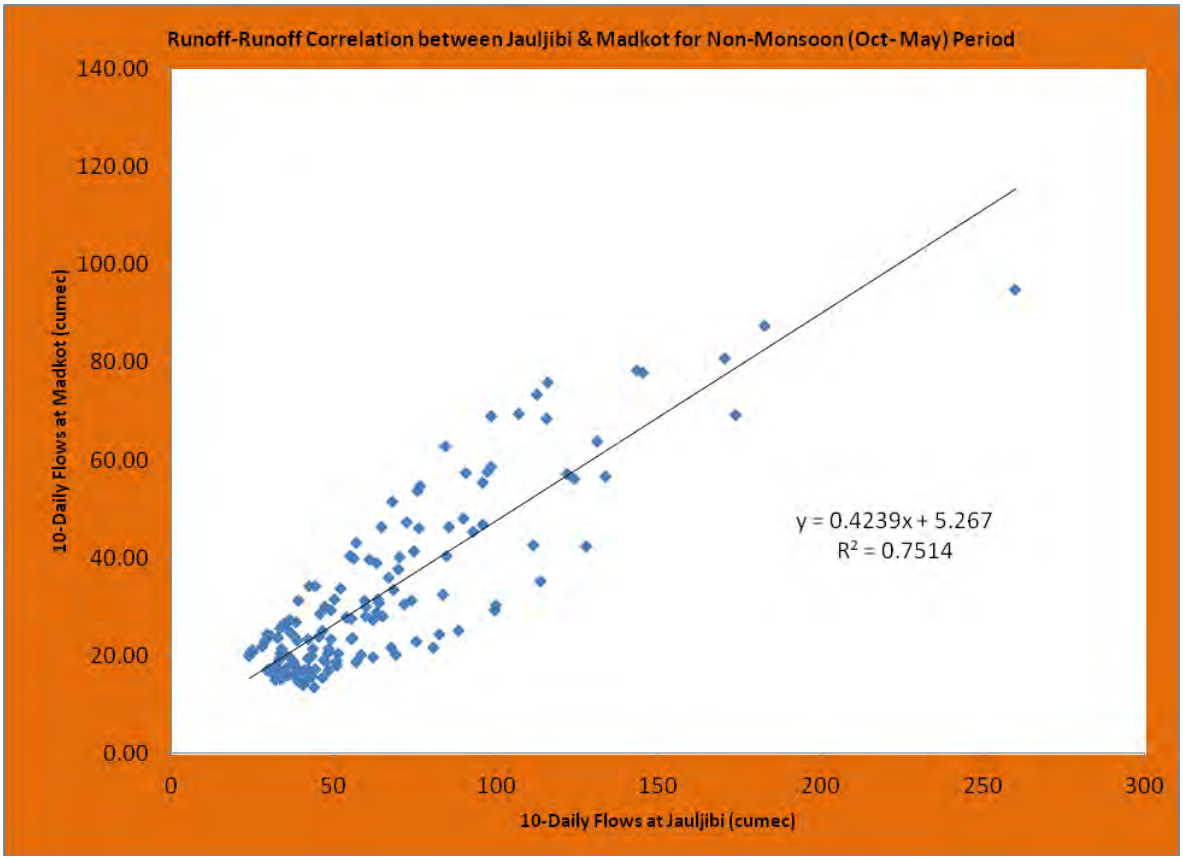


Figure 6.33: Runoff-Runoff correlation between Jauljibi & Madkot for Non-monsoon Period

Utilizing the above runoff-runoff model for monsoon and non-monsoon period, the runoff series at Madkot has been extended for the period June-77 to May-84 and Jan-91 to May-09. The observed-cum-extended series at Madkot is at **Annexure-IX**. This observed-cum-extended flow series at Madkot (CA- 1370 Km^2) is then transposed in catchment area proportion to proposed Sirkari Bhyol-Rupsiabagar HE site (CA- 957 Km^2) to yield a runoff series of 32 years (1977-78 to 2008-09) at the proposed HEP site (attached at **Annexure X**). Since Madkot and proposed project site lies on the same Goriganga river in same hydro-meteorological region and due to non-availability of suitable rainfall data, no impact of rainfall has been considered and transposition has been carried out based on catchment area proportion only. The yield summary at various dependability's is as under (Details attached at **Annexure-XI**):

50% Dependable flow- 1435.69 Mm^3 (1985-86)

75% Dependable flow- 1370.56 Mm^3 (1996-97)

90% Dependable flow- 1180.32 Mm^3 (1987-88)

6.9.1. FLOW DURATION CURVE

The stream flow varies over a water year and the variation has been studied through flow-duration curve. A Flow Duration Curve (FDC) is plotted for 90 % & 50%

dependable year which is a plot of discharge against the percent of time flow equaled or exceeded. The flow duration curve for 90 % & 50 % dependable year in respect of Sirkari Bhyol-Rupsiabagar HEP is indicated in **Figure 1.34** and **Figure** 1**.35** below:.

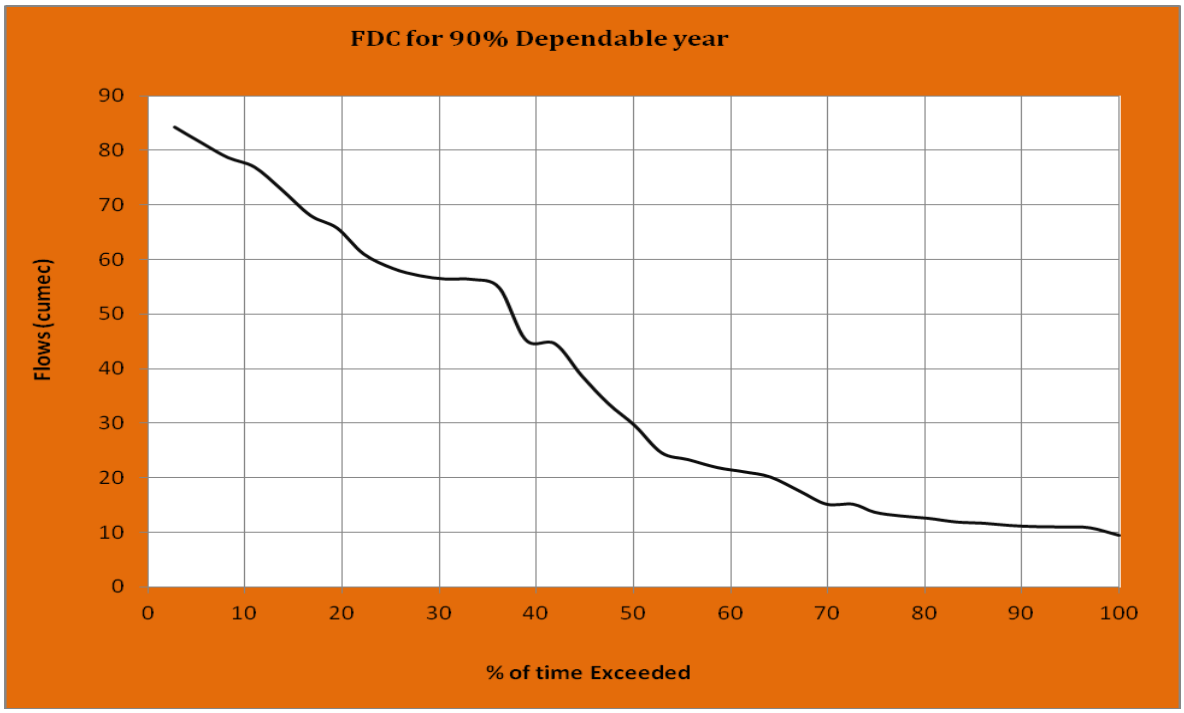


Figure 6.34: Flow Duration Curve for 90% dependable year

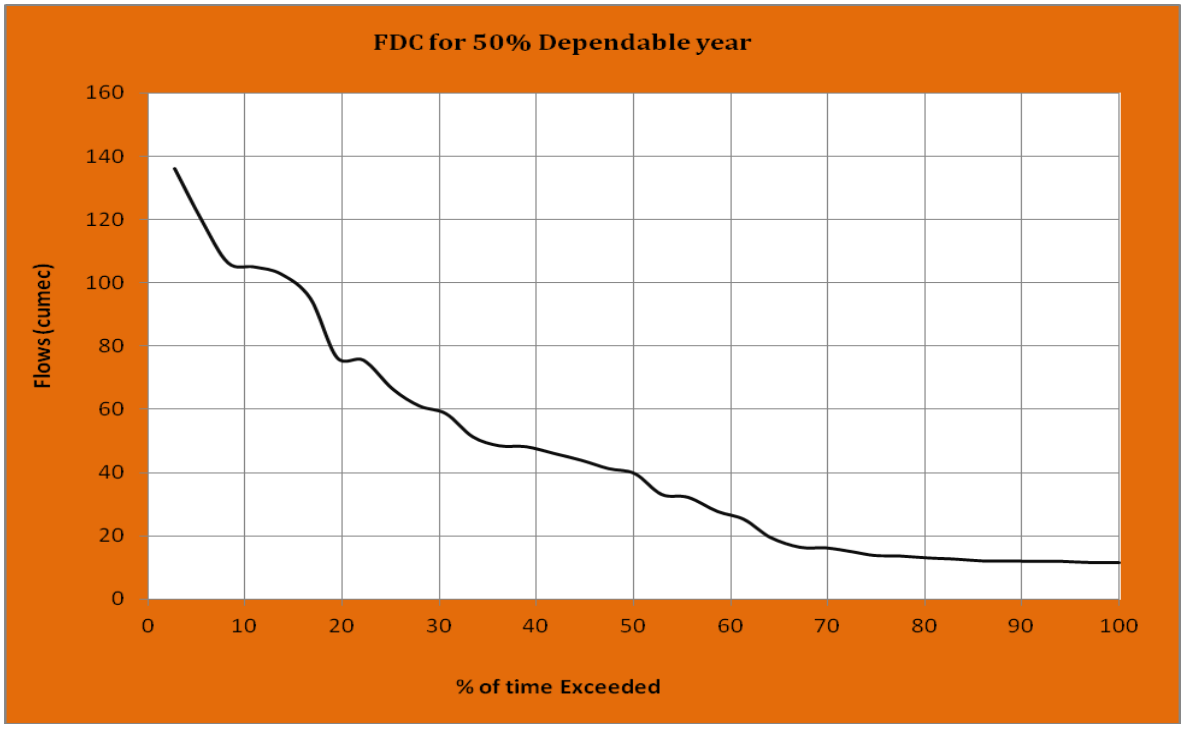


Figure 6.35: Flow Duration Curve for 50% dependable year

6.10. DESIGN FLOOD CRITERIA

The proposed Sirkari Bhyol-Rupsiabagar HE Project envisages construction of approx. 103 m high dam on Goriganga river. The norms / criteria for selection of inflow design flood for safety of dam as per CWC guidelines and BIS (IS 11223 – 1985) codes are detailed below in ***Table 1.8***:

Table 6.8: Criteria for Selection of Inflow Design Flood for safety of Dam as Per BIS/ CWC

Classification	Gross storage	Head at FRL	Inflow design Flood for dam safety
Small	Between 0.5 and 10 MCM	Between 7.5 m to 12 m	100 year flood
Intermediate	Between 10 and 60 MCM	Between 12m and 30 m	Standard project flood (SPF)
Large	Greater than 60 MCM	Greater than 30 m	Probable Maximum Flood (PMF)

The proposed project as such based on BIS criteria could be classified under category of "Large dams". Therefore the structure should be designed to pass the Probable Maximum Flood (PMF).

6.11. DESIGN FLOOD ASSESSMENT

The data available for the studies have been discussed in earlier paras. However, it is reiterated that no site specific short term gauges, discharges, rainfall and flood peaks are available as no SRRG exists in the region. No such data is available in the neighborhood even. As such, unit Hydrograph (UH) based on observed concurrent rainfall and runoff cannot be developed. However, flood peaks for a few years are available at Jauljibi G & D site. The same (flood peaks) are proposed to be utilized to estimate the design flood by flood frequency approach. Further Unit Hydro Graph (UH) approach as indicated in Flood Estimation report for Western Himalayas- Zone 7 by Central Water Commission (CWC), New Delhi is proposed to be utilized for assessment of design flood.

6.11.1. FLOOD FREQUENCY ANALYSIS

Flood frequency analysis is useful in estimating the flood of various return periods for ungauged basins based on the availability of instantaneous flood peak records. The regions which are hydro-meteorologically homogeneous are delineated by similar climate (rainfall and flood producing weather pattern), topography, drainage network and soils. The flood frequency estimation technique ensures a consistent design approach to flood estimation within the homogenous region.

The flood peaks at G & D site is transposed to project site in catchment area proportion using Dickens or other formula to yield series of annual flood peaks at project site. This annual flood peak series is then subjected to frequency analysis to yield floods of various return period at project site. However reliability of flood peak data needs to be ascertained before adoption. Since daily discharge data are available in the Goriganga catchment at Jauljibi, the same are proposed to be utilized for assessment of design flood.

6.11.1.1. Data Processing

Discharges at a G&D site are generally observed once in a day. The historical data as such may (where hourly gauges are not recorded) not include the instantaneous value of peak discharge. As such transposed peaks at project site has been enhanced by 20 % to account for instantaneous values. This instantaneous flood peak are then subjected to frequency analysis to yield floods of various return period at project site. Further, to arrive at reliable estimates from flood frequency analysis, the peak flood value should meet certain criteria with regard to randomness, sample size, quality, outliers etc in the data. The same have been carried out in the present study before adoption. Brief details are as under:

i) Randomness of events

Generally the flood peaks are considered as a sample of random and independent events. The non-randomness of the peak series will increase the degree of uncertainty in the desired frequency relationship. As such before utilization, randomness of peak series

needs to be ascertained and the same have been made before utilization in the present study.

ii) Sample Size

The assumption that the long term flood series data available can provide good estimates of the population parameters and non availability of long term data thus affect the reliability of the estimates obtained from frequency analysis. The number of years of recorded data required to determine reliable estimates therefore depend upon the variability of the data and particular recurrence interval for which the estimate is needed. Generally it is felt that larger the size of data, better results could be anticipated.

iii) Quality of peak discharge data

The results of flood frequency analysis are as reliable as the peak discharge data on which it is based. So quality and reliability of basic data is essential for better results. As such interpretation of peak discharge from gauge readings through rating curve (extrapolation) needs extra caution to ensure their reliability.

iv) Outliers

Outliers are data points which depart significantly from the trend of the data. Frequency analysis of peak flood discharges records is unrealistic in the presence of outliers. As such, detection and treatment of high and low outliers is necessary. Various methods are available for their identification and before adoption of peak series, the same should be carried out. The transposed peaks at the project site were examined for outliers before adoption.

The transposed instantaneous flood peaks at project site based on Jauljibi observed peaks have been analyzed to ensure that the fundamental assumptions of the frequency analysis are satisfied as indicated in earlier paras. The flood peak series at project site have been checked for randomness, outliers, trends and the statistical parameters e.g. mean, standard deviation, coefficient of variance, skewness coefficient and Kurtosis coefficient have been computed. For assessing the probability/return period Weibull formula (m/n+1) has been used where m is the rank of the event and n the total number of events. Based on the results of the statistical tests, frequency analysis by Normal, Gumbel, Log Pearson-III, Log normal-II, and 2-Parameter Gamma distributions have been carried out using HYFA package. The details of frequency analysis is at ***Annexure XII.***

The flood corresponding to various return period at project site are as under:-

Return Period (Yr)	Flood (cumec) at Sirkari Bhyol-Rupsiabagar HEP site
2	534

5	668
10	745
20	842
25	876
50	986
100	1102
500	1404
1000	1550
10000	2125

6.11.2. HYDRO-METEOROLOGICAL APPROACH

The hydro-meteorological approach enables to determine the design flood hydrograph by superimposing the critical sequence of storm rainfall on an appropriate response function of the catchment. Depending upon the size, shape and topographical functions of the catchment, the response function could be represented by a catchment model or in simple terms by a unit hydrograph. Broadly unit hydrograph (UH) is the direct runoff coming from unit effective rainfall distributed over the catchment at a uniform rate during the specified time (unit duration). The Central Water Commission (CWC) in association with India Meteorological Department (IMD), Ministry of Railway and Ministry of Surface Transport (MOST) had carried out rainfall runoff studies of 7 representative catchments for varying periods based on the data collected by Railways under the guidance of R and D wing for estimation of design flood. The Flood Estimation Report for Western Himalaya Zone -7 prepared after the outcome of the study by CWC was for Jammu & Kashmir, Himachal Pradesh, and parts of Punjab and Utter Pradesh, illustrates the procedure for deriving synthetic unit hydrograph based on regression analysis of physiographic parameters so as to estimate the unit hydrograph parameters including lag time, peak rate of discharge, base period and width of unit hydrograph at 75% and 50% of peak discharge The parameter and formula recommended in the report are given below:

t_P	=	$2.498\ (LLc/S)^{0.156}$
q_P	=	$1.048\ (t_p)^{-0.178}$
W_{50}	=	$1.954\ (LLc/S)^{0.099}$
W_{75}	=	$0.972\ (LLc/S)^{0.124}$
W_{R50}	=	$0.189\ (W_{50})^{1.769}$

W_{R75}	=	$0.419\ (W_{75})^{1.246}$	
T_B	=	$7.845\ (t_P)^{0.453}$	
t_m	=	$t_p + t_r/2$	$t_r = 1$
Q_P	=	$q_P \times A$	

Where: -

Q_p : Peak Discharge of Unit Hydrograph (cumec)

q_p : Peak Discharge of Unit Hydrograph per unit area in (cumec per sq.km)

t_p : Time lag from centre of unit rainfall duration to peak of UG (hrs)

t_m : Time from start of rise to peak of UH in (hrs.)

T_B : Base Period of UH (hrs)

W_{50} : Width of UG measured at 50% peak Discharge Ordinate (Q_p) (hrs).

W_{75} : Width of UG measured at 75% peak Discharge Ordinate (Q_p) (hrs).

W_{R50} : Width of the rising side of UG measured at 50% peak Discharge Ordinate (Q_p) (hrs).

W_{R75} : Width of the rising side of UG measured at 75% peak Discharge Ordinate (Q_p) (hrs).

For Sirkari Bhyol-Rupsiabagar HE Project site, following parameters given in **Table 1.9** are determined from Toposheets. The snowline elevation of 4572m has been considered to delineate the snowfed and rainfed area for the project catchment. Further the longest length of river (farthest watershed boundary of rainfed area to the proposed project site) together with the longest main stream from a point opposite to centroid of catchment outlet along the main stream have been computed from the toposheet. The details are given below:-

Table 6.9: Catchment Area Parameters of Sirkari Bhyol-Rupsiabagar HEP

Parameter	Value	Unit
A	957	km^2
A_s	526.48	km^2

A_r	430.52	km^2
L	51	km
L_c	28.80	km
S	44.56	m/km

Where: -

A : Catchment Area (sq.km)

A_s : Snow fed Catchment area (sq.km)

A_r : Rain fed Catchment Area (sq.km)

L : Longest length of main stream along the River course (km)

L_C : Longest length of main stream from a point opposite to centroid of area to the project site (km)

S : Equivalent stream slope (m/km)

On the basis of above, the unit hydrograph parameters have been calculated in the **Table 1.10** below for snow free catchment area only whose details are at **Annexure XIII.**

Table 6.10: UH Parameters for Sirkari Bhyol-Rupsiabagar HEP catchment

Parameter	Value	Unit
t_p	4.3	Hrs.
t_m	4.8	Hrs.
W_{75}	1.5	Hrs.
W_{50}	2.8	Hrs.
W_{R75}	0.7	Hrs.

W_{R50}	1.2	Hrs.
T_B	15.2	Hrs.
Q_P	348.0	Cumec

Based on the above, the unit hydrograph is plotted with the parameters and its ordinates are tabulated as under. While adjusting the UH the runoff volume is computed and the ordinates of unit hydrograph adjusted to give a runoff depth of 1.0 cm over the rain fed catchment, while plotting the UH, care was taken to adjust the UH ordinates such that the value of Q_p, t_m, t_b, W_{75} and W_{50} are not changed. After adjustment the one hour UH ordinates for Sirkari Bhyol-Rupsiabagar HEP catchment are as under. The UH is plotted with these parameters and is shown in **Figure 1.36**. The UH ordinates are given in **Table 1.11**.

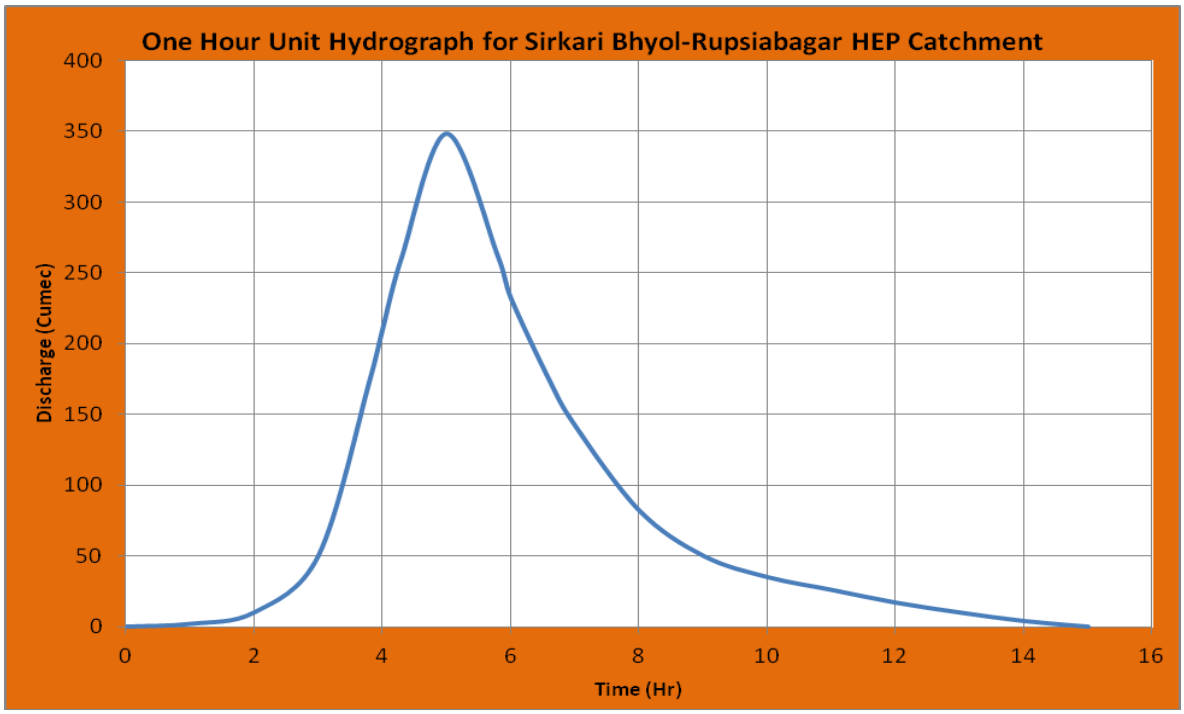


Figure 6.36: 1-Hr Unit Hydrograph Plot for Sirkari Bhyol-Rupsiabagar HE Project

Table 6.11: UH ordinates for Sirkari Bhyol-Rupsiabagar HEP catchment

Time (hrs.)	Discharge in (Cumec)	Time (hrs.)	Discharge in (Cumec)
0	0	8	82
1	2	9	50
2	10	10	35

3	50	11	26
4	210	12	17
5	348	13	10
6	232	14	4
7	142	15	0

6.11.2.1. Design storm

India Meteorological Department (IMD) is carrying out design storm study specifically for Sirkari Bhyol-Rupsiabagar HEP catchment. the study by IMD is under progress and may take some time when the same will be completed by them. Tentatively a study have been (two alternatives) carried out to assess the design flood as under

i) Using Meteorological Monograph prepared by IMD.

ii) Utilizing the 24-hr PMP depth as approved by CWC for Bogudiyar-Sirkari Bhyol HEP (CA- 815 km^2) based on Askote observed data.

a) Alternative-I

For present studies design storm has been taken from "Meteorological Monograph (Hydrology / No 11/ 1988) for 1-day point probable maximum precipitation" prepared by IMD during 1988 and a design 1-day PMP depth of 40 cm (24 hrs) has been adopted. A moisture adjustment factor of 1.3 as used by IMD for computing 1-day PMP, has been considered to compute 1-day SPS of 30.77 cm. These 1-day storm depths were further increased by 15% to yield 24-hour value. Since point PMP is available from Monograph, an Areal Reduction Factor (ARF) of 0.923 has been considered while assessing the flood.

b) Alternative-II

While approving the study of Bogudiyar-Sirkari Bhyol HEP (CA- 815 km^2), located upstream of proposed project, CWC during PMP study of Dhauliganga basin arrived at a value of 54.77 cm for Askote. After applying moisture depletion factor and orographic influence, the 1-day PMP depth for Munsyari Milam was assessed as 193 mm (547.7x0.351) and after considering the clock hour correction, the 24-hr PMP was assessed as 222 mm. The same is proposed to be utilized tentatively (based on the approved PMP depth for upstream project) to assess the design flood pending receipt of PMP and SPS depth from IMD New Delhi for the present proposed HE project.

Short term distribution for converting the 24 hour storm depth is taken from CWC flood estimation Report for Western Himalayas Zone 7 of November 1994. The short term distribution is as under: (**Table 1.12**):

Table 6.12: Short term Percentage distribution of 24-hr Storm depths

Duration	% of 24-hour storm rainfall	Duration	% of 24-hour storm rainfall
0	0	13	79
1	17	14	81.5
2	27	15	84
3	36	16	86
4	43	17	88.2
5	49	18	90
6	54	19	92
7	59	20	94
8	63	21	96
9	67	22	97.5
10	70	23	99
11	73	24	100
12	76		

While carrying out the studies, both single bell and double bells have been used. Two bells of 12 hrs, each has been considered as per current practice with details as under:

24 Hr. Distribution

i) 1st Bell (80% of 24 hr rainfall)

ii) 2nd bell (20% of 24 hr rainfall)

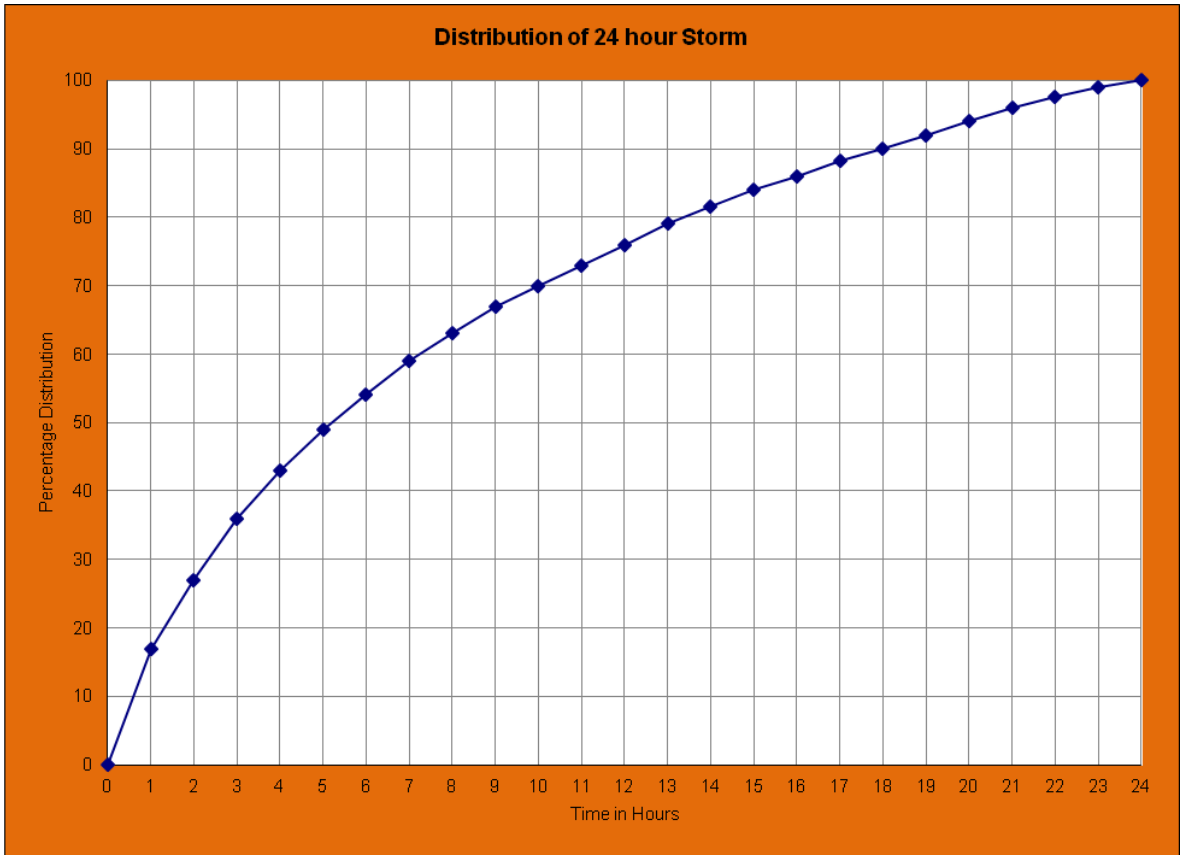


Figure 6.37: Hourly Percentage Distribution of 24-hr Design Storm

6.11.2.2. Loss rate and base flow

A design loss rate of 2.5 mm/hr and a design base flow of 0.05 cumec/km^2 have been considered.

6.11.2.3. Snow melt contribution

The snow melt contribution has been adopted as per WMO No. 168, Manual Equation for heavily forested area adopted from U.S army corp. of Engineers for snow/ glaciers melt due to rain.

$M = (0.3+0.012*P)*T + 1.0$

Where

M= Daily snowmelt in mm

P = Daily rain in mm

T= Mean daily temperature in 0 C (degree centigrade)

The rainfall values have been adopted as PMP and SPS depths. The mean temperature of the snow fed area has been considered as 3^0C.

6.11.2.4. DESIGN FLOOD AT SIRKARI BHYOL-RUPSIABAGAR HEP SITE

Based on the above the Standard Project Flood (SPF) and Probable Maximum Flood (PMF) have been computed using synthetic unit hydrograph developed by CWC manual. The unit hydrograph ordinates and the rainfall excess ordinates corresponding to PMP depth as indicated in earlier paras under the two alternatives have been arranged in critical sequence (both single bell and double bell) and order reversed to get the sequence which have been considered in the study, multiplying each UH ordinate with the net rainfall and then adding together to obtain the direct surface runoff by convolution. After adding base flow and snowmelt contribution the SPF and PMF have been computed. The details are at **Annexure-XIII** and **Annexure-XIV**.

6.11.3. CONCLUSION AND RECOMMENDATIONS

The results of the frequency analysis and Hydro-meteorological study are summarized below in **Table 1.13**:

Table 6.13: Peak flood (cumec) by different alternatives for Sirkari Bhyol-Rupsiabagar HE project

Methodology	Storm Depth (cm)	Return period	Single Bell (cumec)	Double Bell (cumec)	Peak Flood (Cumec)
1-day SPS	30.77	SPF	3684	3681	**3684**
	14.85		1797	1796	**1797**
1-day PMP	40	PMF	4871	4867	**4871**
	19.3		2418	2416	**2418**
Flood Frequency analysis		25			876
		50			986
		100			1102
		1000			1550
		10000			2125

From the tabulated results, it can be seen that there is minor difference in the calculated flood magnitudes from single bell and double bell methods. Considering the results obtained from flood frequency analysis and the results obtained by Synthetic Unit Hydrograph method, the design flood (PMF) recommended for Sirkari Bhyol-Rupsiabagar HE Project is **3645 cumec** (average of peaks estimated by two alternatives) tentatively till site specific PMP study results and reports from IMD are available.

6.12. DIVERSION FLOOD

A 33 year non-monsoon peak series at Sirkari Bhyol-Rupsiabagar HEP site have been assessed on similar lines as indicated in para 1.13.1 above. Flood frequency analysis has been carried out adopting HYFA software using Normal, Log Pearson Type-III, Gumble, Log Normal-II and 2-Parameter Gamma distributions on derived non-monsoon peak

series of Sirkari Bhyol-Rupsiabagar dam site. Floods for various return periods have been estimated. A diversion flood of 291 cumec, corresponding to 25-year non-monsoon return period has been recommended for Sirkari Bhyol-Rupsiabagar HEP. Therefore it is suggested that construction activities may not be carried out during Monsoon period. The details are at **Annexure-XV**.

6.13. SEDIMENTATION

Sirkari Bhyol-Rupsiabagar HE project is a run of river project in which undersluices at lower level have been proposed for flushing out the silt at regular intervals. Suitable sediment management practices will be evolved to avoid sediment deposition. Moreover, intake has been proposed to be located at suitably higher level above the spillway crest to prevent the entry of the silt in the water conductor system. As such sedimentation studies are not required. However, it is suggested that efforts may be made to provide silt free water (Particles greater than 2 mm are not allowed inside the turbines) to ensure that turbine blades are not damaged.

6.14. GLACIAL LAKE OUTBURST FLOOD (GLOF)

The Goriganga is one of the most glaciated rivers of Uttarakhand. The river along with its tributaries and other rivulets in the project drainage area originate from glaciers only. The Milam glacier, from which the Goriganga originates, had been receding. A glacial lake is generally formed in the area so vacated by the glacier and the moraine bounded by ice among them holds the lake water. Under adverse- hot climatic conditions or its own hydraulic pressure such lakes may burst and the resulting wall of flood water along with huge debris mass cause unprecedented destruction in the downstream depending upon the size of the lake and the amount of debris it may carry. Fortunately, all such lakes in the basin are reported to be safe at present and the same have been accepted by CWC for upstream Bogudiyar-Sirkari Bhyol HEP. as such there is no possibility of GLOF for the proposed Sirkari Bhyol-Rupsiabagar HEP at present.

6.15. LIMITATIONS OF THE STUDY AND RECOMMENDATIONS

Hydrological studies have been carried out in the absence of site specific data and short interval rainfall data. The flood study has been carried out in absence of detailed meteorological study including assessment of PMP values from IMD. The flood assessment made in the present study may differ when IMD storm values are utilized. In this connection IMD have been requested to supply relevant storm values and its short term distribution for utilization in flood studies. The Project authorities has already established a hydro meteorological station and measuring daily rainfall and runoff data from October 2010 as per accepted norms and standards. When, sufficient length of site specific data is made available the hydrological studies needs to be reviewed.

भारत सरकार
केन्द्रीय जल आयोग
जलविज्ञान (मध्य) निदेशालय

Subject: DPR of Sirkari Bhyol-Rupsiabagar (SBR) project in Pithoragarh district of Uttarakhand State

Ref: (1) CWC No. 01/Utt/60/2014/Hyd(N)/434-35 dated 22.10.2014
(2) State Govt. No. 1623/ UJVNL/03/Dir(P)/GM(C-NP)/SBR dated 01.10.2016
(3) CWC No. 4/18/2016/Hyd(N)/378-79 dated 16.11.2016

The reference is invited to the above cited letter on the subject. The hydrology report of this project was earlier submitted to CWC in September 2013. The observations on the same were communicated vide this office letter at Ref (1). The reply to these observations have been submitted by Project Authorities vide letter at Ref (2) and communicated to this office vide letter at Ref (3). The same has been examined and observations / comments of this office are as under:

Project Background

Sirkari Bhyol-Rupsiabagar (SBR) project is proposed on Goriganga River in Pithoragarh district of Uttarakhand state. As per DPR of the project submitted in 2013, the project as earlier planned envisaged construction of a 103m high concrete dam, with water from the diversion dam leading to an underground power house, which was earlier planned with an installed capacity of 210 MW (3x70).

Now, as per Brief Note on DPR of the project prepared for first consultation meeting in CEA, submitted to this office, the project now conceived is purely a run-of-river scheme, comprising of a 12m high barrage diverting the design discharge to the underground power house with an installed capacity of 168 MW (4x42). The catchment area of the project is 960 Sqkm including 536 Sqkm under permanent snow cover (considering permanent snow line at an elevation of 4560m). Mapang Dam and Rupsiabagar Khasiabara HEP are the existing projects located upstream and downstream respectively of the SBR project.

Water Availability Studies

Six G&D sites, viz. Rargiri, Madkot, Devbagar, Bangapani, Tham and Jauljibi, are located on Goriganga Rive. The location of the project is close to Rargiri G&D site, where the project site-specific data is available since October 2010 only. At all the nearby G&D sites located downstream of the project site, the discharge data for longer period of time (around 33

years) is available only at Jauljibi. At remaining G&D sites relatively shorter span (less than 13 years) discharge data is available.

Geographically, Madkot G&D site is the nearest to the project site, where discharge data is available for the period from June 1984 to December 1990. Because of the limited data availability at project specific Rargiri G&D site, the catchment area proportionate method has been used in yield calculation utilizing discharge data of Jauljibi as the discharge data at Madkot G&D site could not be used due to its availability for very short span. With the available discharge series at Madkot and Jauljibi G&D sites, the consistency of the runoff data at Madkot G&D site has been checked, and it is found consistent with the Jauljibi G&D site.

A Runoff-Runoff model has been developed for the common years of available data at Jauljibi (1977-78 to to 2014-15) and Madkot (1984-85 to 1990-91) G&D sites. Due to poor data availability at Madkot, runoff-runoff model could not be developed for each month; rather, two separate correlations for monsoon and non-monsoon seasons have been derived. Additionally, to develop a better correlation, observed discharge series at Madkot has been updated for some intermittent years (1991-92 to 1995-96 & 2013-14 to 2014-15) as per details provided by NHPC in respect of Goriganga III A HEP. These equations are tabulated below;

S.No.	Season	Equation	R^2	Remarks
1.	Monsoon	$y = 0.29x + 32.91$	0.769	Where, y refers to the Runoff(MCM) at Madkot site, and x refers to the Runoff(MCM) at Jauljibi G&D site
2.	Non-Monsoon	$y = 0.586x - 0.395$	0.755	

Using these correlations and ten-daily discharge series at Jauljibi site, discharge series at Madkot G&D site (Catchment area 1401 Sqkm) has been extended from 1977-78 to 2014-15. As the project catchment consists of considerable snow-fed area, the discharge series derived for Madkot G&D site includes contribution from snowmelt also. Therefore, catchment area proportionate method has not been applied directly on the discharge series at Madkot. Discharge series has been bifurcated into two components; one, contribution from the rainfall in the project catchment, and the second, contribution from the snowmelt, and the catchment area proportionate method has been applied for each component separately.

Geographic conditions in the region favour the snowmelt during the months of January to June. For the rest of the months of the year, it is assumed that no snowmelt has taken place, and only the rainfall component has contributed to the runoff. Snowmelt rate is largely a function of environment temperature. For a particular month of the year, the average temperature may be assumed constant over a period of 30-40 years. Therefore, the snowmelt rate for a particular month may also be considered uniform over the years. This constant snowmelt rate has been calculated by using the minimum observed/ extended

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discharge data for that month over the period 1977-78 to 2014-15. It is assumed, for that year, in which discharge was minimum, only the snowmelt contribution would have been taken place. Snowmelt rates, thus calculated, are tabulated below;

Month	Jan	Feb	Mar	Apr	May	Jun
Snowmelt Rate (mm/day)	1.24	1.27	1.59	3.11	4.55	7.88

Using these rates, the snowmelt components have been segregated out of the observed/ extended discharge series data.

Rainfall contribution can be calculated by deducting snowmelt contribution from the observed discharge at G&D site. Distribution of the rainfall over the catchment has been checked using TRMM data. It is found that there is a belt of high rainfall area between project site and G&D site at Madkot, which implies that average rainfall in the catchment areas of the project site and Madkot G&D site may differ significantly. In such situations, while applying catchment proportionate method, yield series may be corrected by a factor reflecting this difference in average rainfall in the respective catchments. Here, the correction factor has been taken as the ratio of mean rainfall of the project catchment to the mean rainfall of the G&D site catchment, which in this case works out to be 0.7 (as per TRMM data). As there is no significant rainfall data available in the catchment and considering some degree of error in TRMM data, this factor has been increased to 0.9. The following equation shows the method;

$$Q_{SBR} = Q_{Madkot} * \frac{(A_{SBR})}{(A_{Madkot})} * 0.9$$

Where, Q = Rainfall contribution; A = Rain-fed areas

The snowmelt contribution in different months as computed at G&D site has been transposed in catchment area proportion (catchment areas under permanent snow cover).

The catchment areas of all the projects have been delineated using SRTM data with Arc GIS software:

S. No.	Project	Location (As provided by Project Authorities)	Catchment Area (Sqkm)	Snow-fed Area (Sqkm)
1	Madkot G&D site	Lat - 30°03'38.9"N Long - 80°17'23.8"E	1401	657.4
2	Sirkari Bhyol-Rupsiabagar(SBR) HEP	Lat - 30°11'1.5"N Long - 80°14'05"E	960	536.4

In a discussion held with project authorities, project authorities were requested to submit the details of upstream existing/ proposed projects utilization, so that, that may be taken

into account while assessing water availability at SBR site. In response project authorities informed to this office that all the projects located upstream of this project are 'run of the river schemes with only minimal storage for peaking purpose' and there is no actual or planned diversion for Irrigation purpose. Therefore, the flow series obtained from above method may be considered as virgin flow series as there are no upstream utilizations. The series is enclosed as Annexure-I and the same may be adopted for planning purpose. Summary of the result is as follows:

1.	**50% Dependable yield**	1285 MCM
2.	**75% Dependable yield**	1170 MCM
3.	**90% Dependable yield**	989 MCM

It is suggested that necessary hydro-meteorological network may be established in the project area for collection of site specific discharge and rainfall data and the same may be used to update the hydrological studies after collecting sufficient data.

21.2.2017.
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1/UTT/60/2014/Hyd (N)/131-33 Date: 21.02.2017

Annexur

Monthly Water availability at Sirkari-Bhyol Rupsiabagar HE Project in MCM

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
1977-78	139.4	186.9	191.6	133.7	89.0	48.2	30.1	31.7	26.3	39.8	73.2	162.8	1152.7
1978-79	186.0	181.2	196.2	140.2	82.4	34.0	20.4	21.7	19.0	26.3	50.0	76.7	1034.3
1979-80	126.7	118.7	121.3	74.0	61.9	19.5	15.3	20.7	21.2	35.3	60.3	96.3	770.9
1980-81	139.0	129.0	129.2	101.3	76.3	42.5	24.9	29.4	26.6	35.2	68.8	122.0	924.2
1981-82	169.7	243.1	247.8	115.0	81.7	37.8	24.4	27.9	25.5	39.4	73.1	116.2	1201.4
1982-83	183.6	214.3	261.6	138.9	72.7	31.1	19.2	26.7	24.0	35.1	57.3	150.6	1215.0
1983-84	171.0	175.4	231.9	204.4	100.6	49.5	33.8	29.9	26.1	43.4	58.3	129.1	1253.4
1984-85	235.5	192.3	181.8	130.6	68.2	39.6	34.4	37.9	32.9	44.0	63.3	114.1	1174.6
1985-86	141.0	188.5	235.1	145.8	100.4	48.7	29.3	31.5	27.9	35.0	67.3	122.0	1172.4
1986-87	196.1	228.3	174.5	81.0	38.5	28.0	25.8	29.3	26.1	33.9	51.9	75.7	989.2
1987-88	153.8	143.8	155.6	112.0	49.1	30.4	25.7	28.7	27.7	45.1	79.2	134.8	985.9
1988-89	164.4	205.6	200.4	107.3	61.1	36.2	26.8	32.3	24.9	35.0	54.9	111.0	1060.0
1989-90	162.1	208.6	270.0	191.8	93.0	57.3	43.5	40.7	31.5	43.8	72.8	145.6	1360.6
1990-91	179.0	168.6	194.4	173.8	82.2	50.7	38.7	41.0	36.0	92.5	128.9	157.7	1343.5
1991-92	214.5	225.2	240.9	152.3	96.1	57.3	42.1	43.7	36.5	47.1	72.4	133.5	1361.6
1992-93	201.9	199.2	249.4	176.2	92.7	61.6	29.1	36.4	37.7	56.9	94.8	163.9	1399.8
1993-94	167.3	176.2	214.6	183.8	101.3	69.4	46.5	44.6	37.1	42.5	63.5	142.3	1289.1
1994-95	226.5	208.1	228.6	147.8	85.4	32.3	29.0	29.3	26.6	34.7	62.1	152.3	1262.6
1995-96	207.2	201.0	251.1	199.2	95.7	51.3	35.7	39.0	35.6	50.7	88.1	133.8	1388.5
1996-97	183.9	184.3	213.9	160.9	92.1	47.7	32.1	32.6	28.5	37.0	60.1	89.7	1162.7
1997-98	145.3	195.6	217.5	163.7	82.6	47.1	43.0	39.4	32.1	44.1	88.2	170.2	1268.8
1998-99	187.6	230.7	273.9	147.6	115.4	67.7	43.3	38.7	32.2	38.5	72.4	111.8	1359.7
1999-00	153.2	242.1	236.1	160.4	102.6	53.8	41.0	40.8	36.7	45.9	92.7	180.5	1385.9
2000-01	216.2	222.8	234.1	149.4	89.2	48.0	33.2	36.1	30.4	35.7	61.0	125.4	1281.8
2001-02	171.6	254.9	228.8	130.2	87.1	65.2	43.3	40.0	30.5	65.6	88.0	180.3	1385.4
2002-03	176.9	202.7	213.0	197.9	94.8	46.3	35.1	37.9	33.2	45.8	89.7	132.4	1305.6
2003-04	183.3	231.6	255.2	199.8	104.3	55.9	42.2	38.6	30.7	37.8	57.1	100.4	1336.9
2004-05	143.5	188.9	247.8	145.3	104.8	54.4	45.7	34.0	31.8	43.3	59.2	91.5	1190.1
2005-06	156.2	260.4	263.1	208.5	153.4	140.0	35.9	38.7	35.0	39.8	56.5	144.8	1532.4
2006-07	162.9	260.5	262.3	184.4	99.9	64.1	34.7	34.5	31.2	53.0	96.6	134.0	1418.0
2007-08	201.1	265.4	282.0	237.6	142.0	102.8	70.1	47.9	41.3	59.3	70.3	112.3	1632.1
2008-09	199.6	234.2	228.7	152.7	98.2	55.1	38.6	39.7	31.0	32.5	50.5	86.1	1246.9
2009-10	138.7	153.6	195.7	180.2	119.5	54.7	41.1	40.5	33.7	41.8	65.1	88.3	1152.8
2010-11	129.3	210.2	307.3	275.7	106.2	57.2	37.4	39.7	34.6	44.0	61.8	115.8	1419.1
2011-12	177.6	268.5	292.1	187.8	93.1	63.3	46.4	41.9	33.5	39.9	66.3	111.3	1421.7
2012-13	156.7	210.7	276.8	200.2	95.1	60.1	41.5	40.2	41.3	55.6	80.5	118.1	1376.7
2013-14	270.4	397.1	351.3	208.5	145.6	153.2	60.3	43.2	37.3	46.4	66.1	192.4	1971.8
2014-15	148.9	253.3	310.9	171.4	54.7	35.6	28.9	37.5	34.0	41.4	68.7	125.7	1310.8

Year	Total availability (monsoon + non-monsoon) (MCM)	Descending	Rank	Probability
1977-78	1152.7	1971.8	1	2.56%
1978-79	1034.3	1632.1	2	5.13%
1979-80	770.9	1532.4	3	7.69%
1980-81	924.2	1421.7	4	10.26%
1981-82	1201.4	1419.1	5	12.82%
1982-83	1215.0	1418.0	6	15.38%
1983-84	1253.4	1399.8	7	17.95%
1984-85	1174.6	1388.5	8	20.51%
1985-86	1172.4	1385.9	9	23.08%
1986-87	989.2	1385.4	10	25.64%
1987-88	985.9	1376.7	11	28.21%
1988-89	1060.0	1361.6	12	30.77%
1989-90	1360.6	1360.6	13	33.33%
1990-91	1343.5	1359.7	14	35.90%
1991-92	1361.6	1343.5	15	38.46%
1992-93	1399.8	1336.9	16	41.03%
1993-94	1289.1	1310.8	17	43.59%
1994-95	1262.6	1305.6	18	46.15%
1995-96	1388.5	1289.1	19	48.72%
1996-97	1162.7	1281.8	20	51.28%
1997-98	1268.8	1268.8	21	53.85%
1998-99	1359.7	1262.6	22	56.41%
1999-00	1385.9	1253.4	23	58.97%
2000-01	1281.8	1246.9	24	61.54%
2001-02	1385.4	1215.0	25	64.10%
2002-03	1305.6	1201.4	26	66.67%
2003-04	1336.9	1190.1	27	69.23%
2004-05	1190.1	1174.6	28	71.79%
2005-06	1532.4	1172.4	29	74.36%
2006-07	1418.0	1162.7	30	76.92%
2007-08	1632.1	1152.8	31	79.49%
2008-09	1246.9	1152.7	32	82.05%
2009-10	1152.8	1060.0	33	84.62%
2010-11	1419.1	1034.3	34	87.18%
2011-12	1421.7	989.2	35	89.74%
2012-13	1376.7	985.9	36	92.31%
2013-14	1971.8	924.2	37	94.87%
2014-15	1310.8	770.9	38	97.44%

50% dependable yield	1285	MCM
75% dependable yield	1170	MCM
90% dependable yield	989	MCM

भारत सरकार
केन्द्रीय जल आयोग
जलविज्ञान (मध्य) निदेशालय

Subject: DPR of Sirkari Bhyol-Rupsiabagar (SBR) Hydro-Electric project in Pithoragarh district of Uttarakhand state- Flood Studies.

Ref: (1) CWC No. 01/UTT/60/2014/Hyd(N)/434-35 dated 22.10.2014
(2) No. 1623/UJVN Ltd./03/Dir(P)/GM(C-NP)/SBR dated 01.10.2016
(3) CWC No. 4/18/2016/Hyd(N)/378-79 dated 16.11.2016
(4) CWC No. 01/UTT/60/2014/Hyd(N)/131-33 dated 21.02.2017
(5) CWC No. 01/UTT/60/2014/Hyd(N)/370-74 dated 16.03.2017
(6) No. 407/UJVN Ltd./03/Dir(P)/G.M.(C-NP)/SBR dated 03.04.2017

The reference is invited to the above cited letters on the subject. The hydrology report of this project was earlier submitted to CWC in September 2013. The observations on the same were communicated vide this office letter at Ref (1). The reply to these observations were submitted by Project Authorities vide letter at Ref (2) and communicated to this office vide letter at Ref (3). The same was examined and Water Availability Studies of the project has already been cleared vide letter at Ref (4). This office has now examined the Design Flood and Diversion Flood Studies of the project and the observations/comments on the same are as under:

Project Background

Sirkari Bhyol-Rupsiabagar (SBR) Hydro-Electric project is proposed on Goriganga river in Pithoragarh district of Uttarakhand state. As per DPR of the project submitted in 2013, the project as earlier planned envisaged construction of a 103 m high concrete gravity dam, with water from the diversion dam leading to an underground power house, which was earlier planned with an installed capacity of 210 MW (3x70).

As per Brief Note on DPR of the project prepared for first consultation meeting in CEA, submitted subsequently to this office, the project now conceived is purely a run-of-river scheme, comprising of a 12 m high barrage diverting the design discharge to the underground power house with an installed capacity of 168 MW (4x42). The catchment area of the project is 960 sq km including 536 sq km under permanent snow cover (considering permanent snow line at an elevation of 4560 m). Mapang dam and Rupsiabagar khasiabara HEP are the existing projects located upstream and downstream respectively of the SBR project.

Design Flood Study

In absence of short interval rainfall runoff data, Project Authorities have derived unit hydrograph synthetically for the SBR Project using Flood Estimation Report for Western Himalayas - sub zone 7. IMD has carried out the SPS & PMP studies of the project and recommended 1-day SPS & PMP values as 233 mm and 342 mm respectively, whereas the

corresponding 2-day values are 422 mm and 624 mm respectively. IMD has also provided Temporal Distribution (3-hourly) for 24-hour and 48-hour storm rainfall.

Project Authorities have computed design flood based on 1-day SPS depth of 233 mm (24-hr SPS depth of 268 mm) as well as 1-day PMP depth of 342 mm (24-hr PMP depth of 393.3 mm). Accordingly, the design flood values computed by Project Authorities are **SPF as 2581 cumecs and PMF as 3827 cumecs**.

Analysis:

(i) Gross storage at FRL and Hydraulic Head at FRL have been reported as 0.14 MCM and 9 metres respectively in the DPR submitted by the Project Authority. Accordingly the project can be classified as Small based on the IS 11223-1985 Code. Thus, the project qualifies for 100-Year return period flood as Inflow design flood for the safety of the dam. In the absence of site-specific runoff data, the 100 year return period flood may be computed from 1 in 100 year return period storm using the hydro-meteorological approach.

(ii) Catchment of the SBR project comprises of both snowfed and rainfed areas. Adopting Permanent Snowline at 4560 m, the total catchment area of the project is 960.56 sq km, out of which 536.37 sq km is the snowfed and 424.18 sq km is the rainfed area. The unit hydrograph has been derived synthetically for the rainfed catchment only using Flood Estimation report for sub zone 7. Unit Hydrograph has been smoothened before using in convolution. Base Period of the Unit Hydrograph has been obtained as 15 hrs. Therefore, 1-day storm rainfall should suffice for computing the design flood.

(iii) Isopluvial map of 24-hr 100 year return period storm prepared by IMD in its "Atlas of State-wise Generalised Isopluvial (Return Period) Maps of Northern India (Part-IV) – February, 2009" has been used for estimating the 1-day storm. From the isopluvial maps, the 24-hr 100 year return period rainfall depth comes to about 310 mm. For converting the point rainfall obtained from isopluvial map into areal rainfall, an Area Reduction Factor (ARF) of 0.93 has been applied for rainfed area as per FER.

(iv) Temporal distribution of 24-hour storm rainfall as provided in the FER of sub zone-7 has been used for obtaining hourly contribution of rainfall. Loss rate of 2 mm/hr has been taken into account from FER of sub zone-7 while calculating the effective rainfall i.e. excess rainfall in the basin. Base flow has been taken from FER of sub zone-7 as 0.05 $m^3/s/Sq.$ Km. The Unit Hydrograph ordinates and the rainfall excess ordinates have been arranged in critical sequence (double bell) and order reversed to get the sequences which have been considered in the study.

(v) Snowmelt contribution has been obtained using WMO No. 168 Manual Equation for heavily forested area adopted from U.S. Army Corp. Of Engineers for snow/ glaciers melt due to rain. Area Reduction Factor (ARF) of 0.91 has been applied for snowfed area, as per FER.

$M = (0.3+0.012*P)*T + 1.0$

where, M = Daily snowmelt in mm

P = Daily rainfall in mm. Taken as 310*0.91=282.1mm (0.91 is the ARF factor)

T = Mean daily temperature in ^0C. Taken as 3^0C

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(vi) Base flow and Snowmelt contribution have been added to the direct surface runoff obtained by convolution to get the peak Design Flood, which comes to **3367 cumecs,** corresponding to the 24-hour 100 year return period storm value of 310 mm obtained from Isopluvial map.

(vii) As per IS 6966 (Part 1): 1989, a minimum of 500 year frequency flood or the Standard Project Flood (SPF) is considered desirable flood discharge for the purpose of designing the freeboard. The SPF value based on the 24-hr SPS depth of 268 mm as per IMD Storm Study, using the UG Parameters as mentioned above comes to **2501 cumecs**, which is less than the one obtained from 24-hour 100 year return period storm.

(viii) In view of an apparent anomaly of the SPF value being less than 100 year return period flood, IMD was requested vide this office letter at ref (5) to review both the SPS value obtained in their project specific Design Storm Study as well as the 24-hour 100 year return period storm depth relevant for the catchment of the project as indicated in their isopluvial maps. In their reply vide letter at ref (6), IMD has informed that the observational network in the study area is sparse, and also that the SPS value is based on the highest observed rainfall and therefore it may not be compared with return period values.

(ix) In view of above, an attempt was made to compute the peak design flood for the project using discharge data at a nearby location. CWC has its G&D observation site at Jauljibi (catchment area 2235 sq km), which is about 50 km downstream of the proposed project site. The annual peaks of daily flow are available for 40 years (1976-77 to 2015-16) at the G&D Site. These annual flood peaks have been analysed through flood frequency approach to obtain 100-years return period design flood value.

(x) The observed values of annual flood peaks have been increased by 30% to make them instantaneous as the time to peak obtained from the unit hydrograph developed for the catchment is between 4 to 5 hours and thus there is a greater chance of missing the flood peak in daily observation.

(xi) Results obtained from the 'Gumbel' frequency distribution of instantaneous flood peaks at Jauljibi G&D Site have been used to compute the various return period floods for the Project in the proportion to the ratio of (Catchment area)$^{0.75}$ and the same are tabulated below:

S.No.	RETURN PERIOD	FLOOD VALUES OBTAINED FOR THE PROJECT SITE (cumec)
1	50 Years	1072
2	**100 Years**	**1174**
3	500 Years	1409
4	1000 Years	1510

Recommendation:

With the Peak Design Flood value computed by using IMD isopluvial map for the catchment of the project being inconsistent with the SPF value based on SPS depth provided in the project specific Design Storm Study by IMD for the project, this office has attempted to calculate the 100-year return period flood for the project site based on the discharge data of

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a downstream G&D site with the help of Flood Frequency Approach. While the SPF value is obtained as 2501 cumecs, the 100 year return period design flood value, based on the Jauljibi site in the downstream of the proposed project location, comes to 1174 cumecs. However, in view of the latter value being too low in comparison to the SPF value and also in view of the fact that the observational network in the study area is sparse as communicated by IMD, it is recommended to use the Design Flood for the project as the higher of the two values as per IS:5477 (Part IV) – 1971, which says that in the case of permanent barrages and minor dams with less than 6000 hectare metres (60 MCM) storage, the standard project flood (SPF) or a 100 year flood, whichever is higher, is to be adopted as peak design flood.

Hence, the value of Peak Design Flood computed as 2501 Cumec is recommended for planning and design purpose. (Annexure- 1 to 6)

Diversion Flood Study

Diversion flood for the SBR Project has been evaluated as the maximum of the following two criteria: a) Maximum non-monsoon flow observed at the project site OR; b) 25-year return period flow, calculated on the basis of non-monsoon yearly peaks. The peak of daily flow for non-monsoon months, available for 33 years at Jauljibi G&D Site was provided by Project Authority and used in our analysis. The 25-year return period flow was calculated using the 'Gumbel' frequency distribution. The diversion flood obtained and recommended is as follows:

Project Site	Flow (cumec)		
	Max. Observed (non-monsoon)	25-year return period (non-monsoon)	Recommended Diversion Flood
SBR	320	302	**320**

This issues with the approval of CE, HSO, CWC.

13/4/2017

(S.K. Sinha)
Director

General Manager (Civil-New Projects), UJVN Ltd. Ganga Bhawan, Yamuna Colony, Dehradoon- 248001

No. 01/UTT/60/2014/Hyd(N)/ 303-305 Dated: 13.04.2017

Copy to:

1. Director, Project Appraisal (North) Dte., CWC, New Delhi
2. Director, PAC Dte., CEA, Sewa Bhawan, New Delhi

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Annexure- 1

SBR Project Site

Equivalent stream slope (SBR)						
S.No.	Reduced Distance (Km)	Reduced Level (m)	Length of each segment Li (km)	Height above Datum Di (m)	Di-I + Di	Li*(Di-1 + Di)
1	0.0	2092	0	0	0	0
2	5.5	2338	5.5	246	246	1345.62
3	10.5	2778	5	686	932	4660.00
4	15.5	3113	5	1021	1707	8535.00
5	20.5	3179	5	1087	2108	10540.00
6	25.5	3252	5	1160	2247	11235.00
7	30.5	3347	5	1255	2415	12075.00
8	35.5	3485	5	1393	2648	13240.00
9	40.5	3872	5	1780	3173	15865.00
10	45.5	4148	5	2056	3836	19180.00
11	50.5	4560	5	2468	4524	22620.00
			50.47		∑Li*(Di-1 + Di)	119295.62

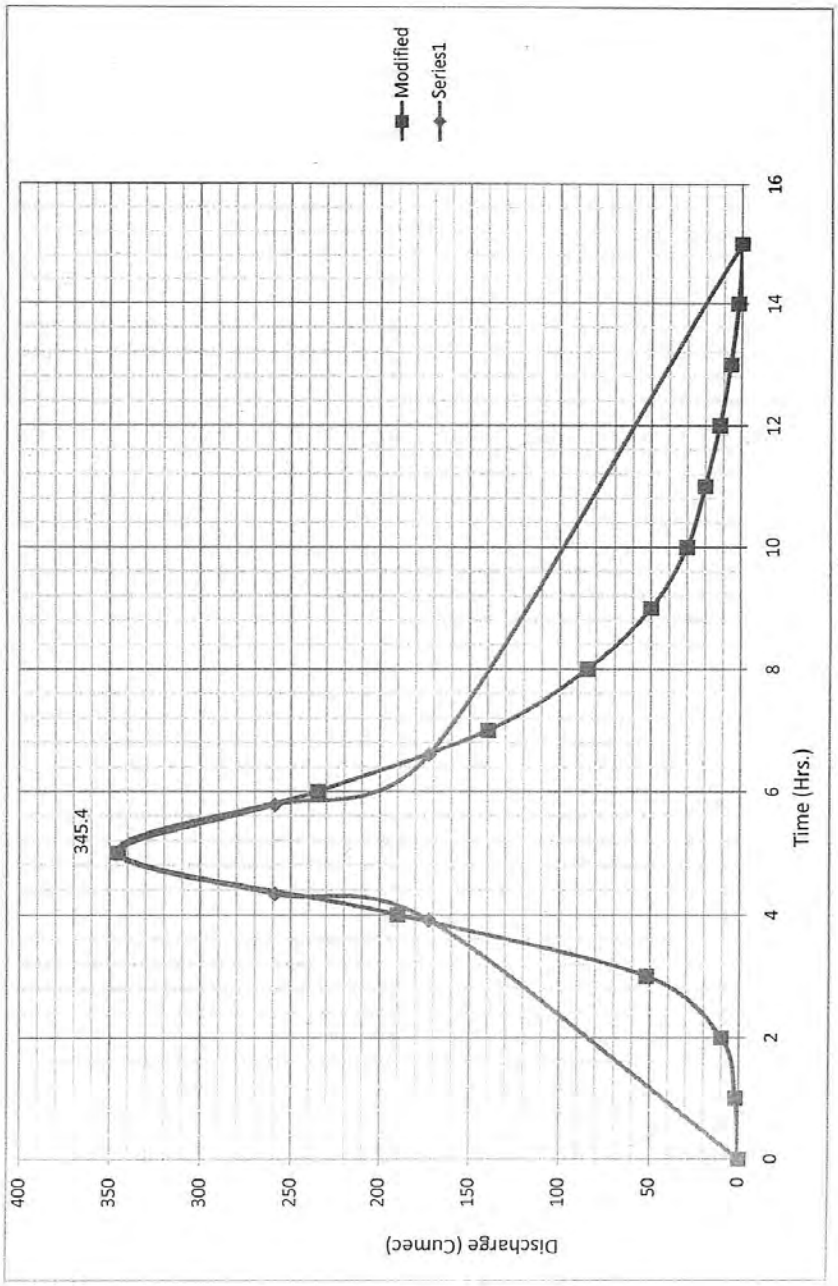
Physiographic parameters		
A	424.19	Km^2
L	50.47	Km
Lc	23.24	Km
S	46.83	m/Km

UG Parameters		
Parameter	Value	Unit
tp	4.13	hour
qp	0.81	cumec/SqKm
W50	2.69	hour
W75	1.45	hour
WR50	1.09	hour
WR75	0.67	hour
TB	14.91	hour
Tm	5.00	hour
Qp	345.39	m3/sec

UG Ordinates	
Time	Discharge
0	0
1	2
2	10
3	52
4	190
5	**345.4**
6	235
7	140
8	85
9	50
10	30
11	20
12	12
13	6
14	2
15	0

Annexure- 2

UG For SBR Project



Annexure- 3

Temporal Distribution of Design Dtorm for SBR Project

Temporal Distribution Provided by IMD (3-hourly)	
DURATION (hrs.)	% DISTRIBUTION OF 24-Hrs.
0	0
3	28
6	47
9	61
12	73
15	83
18	90
21	96
24	100

Hourly Temporal Distribution	
DURATION (hrs.)	% DISTRIBUTION OF 24-Hrs.
0	0
1	11
2	20
3	28
4	35
5	42
6	47
7	52
8	57
9	61
10	65
11	69
12	73
13	77
14	80
15	83
16	86
17	88
18	90
19	92
20	94
21	96
22	98
23	99
24	100

Annexure- 4

Rainfall Distribution

Design Storm : SPS

Area (sqkm)	1 day (mm)
424.19	268

SPS	268

1st day areal SPS depth	1st bell of 12 hours =41.97X0.73	=	19.56	cm
	2nd bell of 12 hours = 41.97X0.27	=	7.24	cm

Table - 4 : Rainfall distribution - 1st day 1st bell

Time (hour)	Distribution coefficient	Cummulative Rainfall depth (cm)	Increment Rainfall depth (cm)	Loss Rate (cm/hr)	Effective Rainfall depth	UG Ordinate	Critical sequencing of rainfall excess	Critical sequencing in reverse order
1	0.15	2.95	2.95	0.20	2.75	10	0.87	0.87
2	0.27	5.36	2.41	0.20	2.21	52	1.14	0.87
3	0.38	7.50	2.14	0.20	1.94	190	1.94	0.87
4	0.48	9.38	1.88	0.20	1.68	345.4	2.75	1.14
5	0.58	11.26	1.88	0.20	1.68	235	2.21	1.14
6	0.64	12.60	1.34	0.20	1.14	140	1.68	1.68
7	0.71	13.94	1.34	0.20	1.14	85	1.68	1.68
8	0.78	15.28	1.34	0.20	1.14	50	1.14	2.21
9	0.84	16.35	1.07	0.20	0.87	30	1.14	2.75
10	0.89	17.42	1.07	0.20	0.87	20	0.87	1.94
11	0.95	18.49	1.07	0.20	0.87	12	0.87	1.14
12	1.00	19.56	1.07	0.20	0.87	6	0.87	0.87
			19.56	Total	17.16			

Rainfall distribution - 1st day 2nd bell

Time (hour)	Distribution coefficient	Commulative Rainfall depth (cm)	Increment Rainfall depth (cm)	Loss Rate (cm/hr)	Effective Rainfall depth	UG Ordinate	Critical sequencing of rainfall excess	Critical sequencing in reverse order
1	0.15	1.09	1.09	0.20	0.89	10	0.20	0.20
2	0.27	1.98	0.89	0.20	0.69	52	0.30	0.20
3	0.38	2.78	0.79	0.20	0.59	190	0.59	0.20
4	0.48	3.47	0.69	0.20	0.49	345.4	0.89	0.30
5	0.58	4.16	0.69	0.20	0.49	235	0.69	0.30
6	0.64	4.66	0.50	0.20	0.30	140	0.49	0.49
7	0.71	5.15	0.50	0.20	0.30	85	0.49	0.49
8	0.78	5.65	0.50	0.20	0.30	50	0.30	0.69
9	0.84	6.05	0.40	0.20	0.20	30	0.30	0.89
10	0.89	6.44	0.40	0.20	0.20	20	0.20	0.59
11	0.95	6.84	0.40	0.20	0.20	12	0.20	0.30
12	1.00	7.24	0.40	0.20	0.20	6	0.20	0.20
			7.24	Total	4.84			

Annexure-5

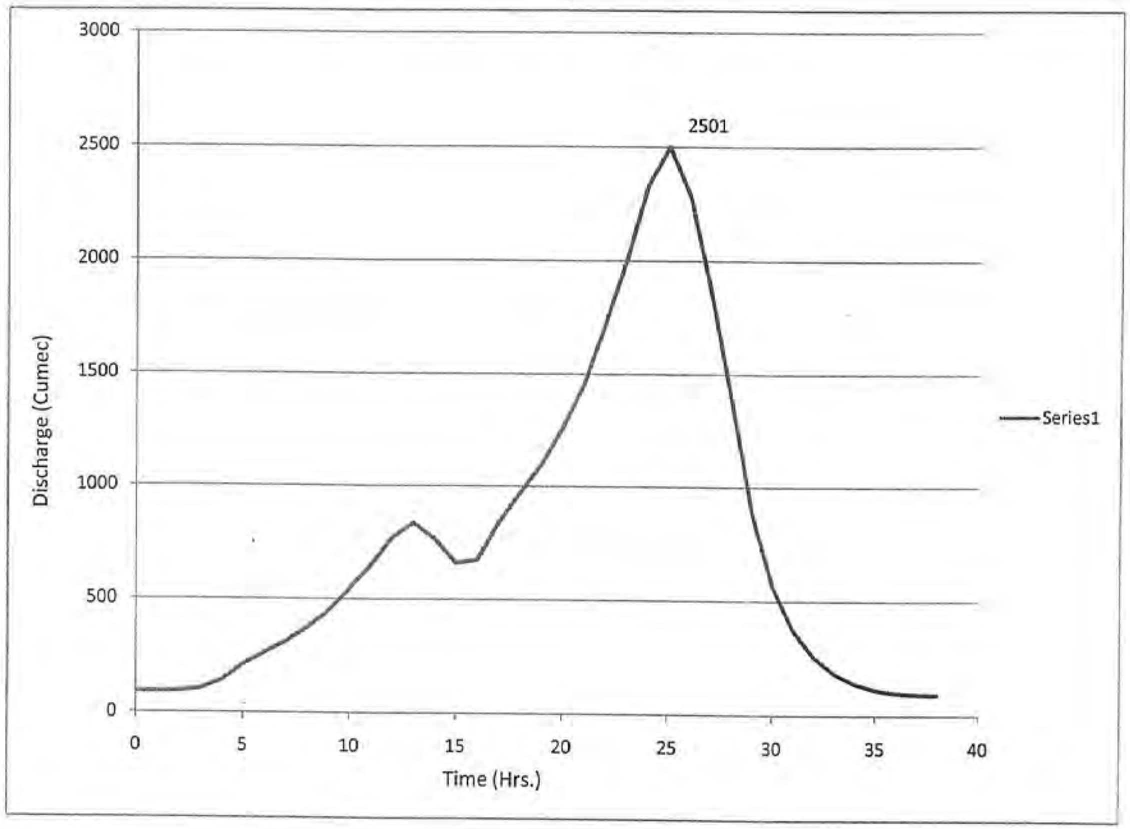
Convolution for Computing Design Flood (SPF) for SBR Project

Time (Hrs)	UG Ordinate	Rinfall excess (cm)																								Base Flow (Cumec)	Snow-melt (Cumec)	Discharge (Cumec)	Time (Hrs.)
		0.20	0.20	0.20	0.30	0.30	0.49	0.49	0.69	0.89	0.59	0.30	0.20	0.87	0.87	0.87	1.14	1.14	1.68	1.68	2.21	2.75	1.94	1.14	0.87					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24					
0	0	0																								0	21.21	71.69	93	0
1	2	0.39	0.00																							0.39	21.21	71.69	93	1
2	10	1.96	0.39	0.00																						2.36	21.21	71.69	95	2
3	52	10.22	1.96	0.39	0.00																					12.58	21.21	71.69	105	3
4	190	37.33	10.22	1.96	0.59	0.00																				50.11	21.21	71.69	143	4
5	345.4	67.87	37.33	10.22	2.96	0.59	0.00																			118.97	21.21	71.69	212	5
6	235	46.18	67.87	37.33	15.37	2.96	0.99	0.00																		170.69	21.21	71.69	264	6
7	140	27.51	46.18	67.87	56.17	15.37	4.94	0.99	0.00																	219.02	21.21	71.69	312	7
8	85	16.70	27.51	46.18	102.11	56.17	25.68	4.94	1.38	0.00																280.66	21.21	71.69	374	8
9	50	9.82	16.70	27.51	69.47	102.11	93.83	25.68	6.92	1.78	0.00															353.83	21.21	71.69	447	9
10	30	5.89	9.82	16.70	41.39	69.47	170.58	93.83	35.99	8.90	1.19	0.00														453.77	21.21	71.69	547	10
11	20	3.93	5.89	9.82	25.13	41.39	116.06	170.58	131.50	46.30	5.93	0.59	0.00													557.12	21.21	71.69	650	11
12	12	2.36	3.93	5.89	14.78	25.13	69.14	116.06	239.05	169.17	30.84	2.96	0.39	0.00												679.70	21.21	71.69	773	12
13	6	1.18	2.36	3.93	8.87	14.78	41.98	69.14	162.65	307.53	112.67	15.37	1.96	1.74	0.00											744.16	21.21	71.69	837	13
14	2	0.39	1.18	2.36	5.91	8.87	24.69	41.98	96.90	209.23	204.82	56.17	10.22	8.72	1.74	0.00										673.18	21.21	71.69	766	14
15	0	0.00	0.39	1.18	3.55	5.91	14.82	24.69	58.83	124.65	139.35	102.11	37.33	45.34	8.72	1.74	0.00									568.62	21.21	71.69	662	15
			0.00	0.39	1.77	3.55	9.88	14.82	34.61	75.68	83.02	69.47	67.87	165.68	45.34	8.72	2.28	0.00								583.07	21.21	71.69	676	16
				0.00	0.59	1.77	5.93	9.88	20.76	44.52	50.40	41.39	46.18	301.19	165.68	45.34	11.40	2.28	0.00							747.31	21.21	71.69	840	17
					0.00	0.59	2.96	5.93	13.84	26.71	29.65	25.13	27.51	204.92	301.19	165.68	59.28	11.40	3.35	0.00						878.14	21.21	71.69	971	18
						0.00	0.99	2.96	8.31	17.81	17.79	14.78	16.70	122.08	204.92	301.19	216.60	59.28	16.76	3.35	0.00					1003.52	21.21	71.69	1096	19
							0.00	0.99	4.15	10.68	11.86	8.87	9.82	74.12	122.08	204.92	393.76	216.60	87.15	16.76	4.42	0.00				1166.19	21.21	71.69	1259	20
								0.00	1.38	5.34	7.12	5.91	5.89	43.60	74.12	122.08	267.90	393.76	318.44	87.15	22.12	5.50	0.00			1360.31	21.21	71.69	1453	21
									0.00	1.78	3.56	3.55	3.93	26.16	43.60	74.12	159.60	267.90	578.89	318.44	115.02	27.48	3.89	0.00		1627.92	21.21	71.69	1721	22
										0.00	1.19	1.77	2.36	17.44	26.16	43.60	96.90	159.60	393.86	578.89	420.28	142.90	19.44	2.28	0.00	1906.66	21.21	71.69	2000	23
											0.00	0.59	1.18	10.46	17.44	26.16	57.00	96.90	234.64	393.86	764.02	522.12	101.09	11.40	1.74	2238.61	21.21	71.69	2332	24
												0.00	0.39	5.23	10.46	17.44	34.20	57.00	142.46	234.64	519.82	949.16	369.36	59.28	8.72	2408.17	21.21	71.69	2501	25
													0.00	1.74	5.23	10.46	22.80	34.20	83.80	142.46	309.68	645.78	671.46	216.60	45.34	2189.56	21.21	71.69	2282	26
														0.00	1.74	5.23	13.68	22.80	50.28	83.80	188.02	384.72	456.84	393.76	165.68	1766.55	21.21	71.69	1859	27
															0.00	1.74	6.84	13.68	33.52	50.28	110.60	233.58	272.16	267.90	301.19	1291.49	21.21	71.69	1384	28
																0.00	2.28	6.84	20.11	33.52	66.36	137.40	165.24	159.60	204.92	796.27	21.21	71.69	889	29
																	0.00	2.28	10.06	20.11	44.24	82.44	97.20	96.90	122.08	475.31	21.21	71.69	568	30
																		0.00	3.35	10.06	26.54	54.96	58.32	57.00	74.12	284.35	21.21	71.69	377	31
																			0.00	3.35	13.27	32.98	38.88	34.20	43.60	166.28	21.21	71.69	259	32
																				0.00	4.42	16.49	23.33	22.80	26.16	93.20	21.21	71.69	186	33
																					0.00	5.50	11.66	13.68	17.44	48.28	21.21	71.69	141	34
																						0.00	3.89	6.84	10.46	21.19	21.21	71.69	114	35
																							0.00	2.28	5.23	7.51	21.21	71.69	100	36
																								0.00	1.74	1.74	21.21	71.69	95	37
																									0	0	21.21	71.69	93	38

Annexure- 6

Design Flood Hydrograph (SPF) for SBR Project

Time (hr)	Discharge (cumec)	Time (hr)	Discharge (cumec)
0	93	20	1259
1	93	21	1453
2	95	22	1721
3	105	23	2000
4	143	24	2332
5	212	25	**2501**
6	264	26	2282
7	312	27	1859
8	374	28	1384
9	447	29	889
10	547	30	568
11	650	31	377
12	773	32	259
13	837	33	186
14	766	34	141
15	662	35	114
16	676	36	100
17	840	37	95
18	971	38	93
19	1096		



Annexure – II: Pre-DPR chapters on Power Potential studies

7. POWER POTENTIAL AND ENERGY AVAILABILITY STUDIES

7.1. INTRODUCTION

Sirkari Bhyol Rupsiabagar Hydro-electric project is located in Munsiyari Tehsil of District Pithoragarh of Uttarakhand. The diversion structure is located at Latitude : $30^0$11'2.5" and Longitude: $80^0$13'49". The Project envisages utilization of the waters of the river Goriganga, a tributary of river kali, for power generation in a run of river type development harnessing a gross head of 357.83 m at FRL. River Goriganga is a very steep river with bed slope of the order of 1 in 10. The substrata conditions, wherein bed rock is available at more than 30 m depth below river bed level, along with steep valley resulting in very low storage do not permit the construction of high diversion structure. The river hydraulics with supercritical flow in such steep river also does not permit the construction of a high diversion structure and there is no precedence of having such a diurnal storage structure in such steep river slopes. The diversion structure has therefore been considered for a purely run of the river scheme. The project components comprise of a 12 m high (from river bed) Barrage, an Intake structure, 2 Nos. Feeder Tunnels each 3.0 m dia., 2 Nos. Underground Desilting Chambers, 4.20 m dia. horse-shoe shaped 1.30 km long HRT, 8 m dia. Surge Shaft, 3.4 m dia. Pressure shaft/tunnel, an underground Power House and Tail Race Tunnel. The FRL and MDDL have been fixed at 2080 m and 2078 m respectively for the Barrage structure.

Sirkari Bhyol Rupsiabagar HEP is third project from upstream in the series of seven cascade developments planned on the Goriganga River. Following hydropower schemes have been planned on the Goriganga river.

S.NO.	NAME OF SCHEME	FRL (m)	TWL (m)
1.	Mapang-Bogudiyar	2960.0	2440.0
2.	Bogudiyar-Sirkari Bhyol	2440.0	2120.0
3.	Sirkari Bhyol-Rupsiabagar	2120.0	1720.0
4.	Rupsiabagar - Khasiyabara	1720.0	1237.0
5.	Devi Bagar – Khartoli (Goriganga III-A)	1237.0	976.0
6.	Khartoli Lumti Talli	976.0	913.0
7.	Goriganga Stage II	913.0	710.0

Since this project lies in the cascade development of the river, the FRL and TWL of the project will be governed by the limitations imposed by upstream and downstream projects. The FRL for the project is therefore governed by the Tail Water level of Bogudiyar-Sirkari Bhyol HE Project, which is the immediate upstream project. The TWL will be governed by the FRL of the downstream project i.e Rupsiabagar Khasiabada HE Project.

As can be seen from above, initially an FRL of 2120m and TWL of 1720m have been allotted to UJVN Limited for developing the Sirkari Bhyol Rupsiabagar HEP. The initial TOR clearance for the project was granted by Expert Appraisal Committee, MoEF vide its letter dated 17th August,2009 with the condition of maintaining a free flow riparian stretch of river between the two projects. The revised TOR clearance was granted in 88th EAC meeting (26th to 27th Oct,2015 (copy of the letter/MOM is enclosed as ***ATTACH A***). Considering this directive from the MoEF along with the revised guidelines which have come into effect recently, following considerations have been made into the power potential studies

A) Reduction of FRL from originally planned EL 2120m to EL 2080.0m to make provision for free river stretch of about 400m. It is assumed that similar action would be taken up by the developer of the upstream project i.e Bogudiyar- Sirkari Bhiol HEP by raising the TWL to increase the length of free river stretch.

B) No raising of TWL is required for Sirkari Bhyol Rupsiabagar HEP since the immediate downstream i.e. Rupsiabagar – Khasiyabada HEP which was proposed to be developed by NTPC has been shelved due to wildlife and reserve forest consideration and will not be taken up for development.

C) Following Environmental flows has been considered to be released immediately downstream of the Barrage to sustain the aquatic species during the lean season and maintaining the flood pulses during the monsoon period as below:

1. Lean Period (November – Feb) – 20% of the average of the four leanest months of 90% dependable year (1.87 cumecs).
2. Monsoon Period (June- September) – 30% of the average flow during the monsoon months of 90% dependable year (14.13 cumecs).
3. Non Lean period (Dec and Oct, April and May) – 25% of the average of the four non-lean months of 90% dependable year (6.42 cumecs).

Basic Data

PARAMETER	MAGNITUDE
Full Reservoir Level (FRL)	2080.00 m

Minimum Drawn Down Level (MDDL)	2078.00 m
Normal Tail Water Level (3 units in operation)	1721.50 m
Minimum Tail Water Level (1 unit at 10% load)	1720.00 m
Average Operating level of the Reservoir in the Non-monsoon Period	= MDDL+2/3 (FRL-MDDL) = 2078+2/3(2080-2078) = 2079.33 m
Head Loss	6.37 m

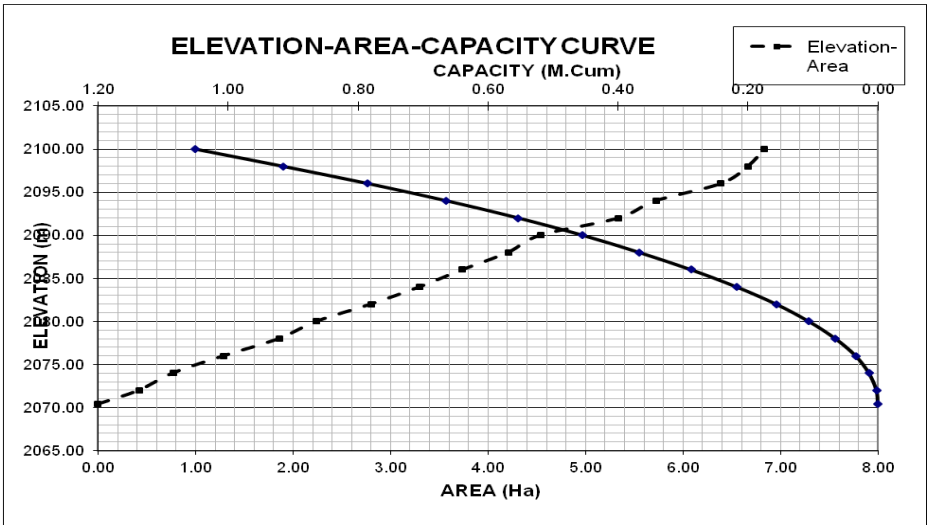
In this study, 10-daily hydrological inflow series in cumec at the Sirkari Bhyol Barrage site has been adopted as per the hydrological studies carried out based on 38 years long term data. **The flow series has been approved by Central Water Commission.**

The flow series adopted is presented in **Annexure – 7.1** and the same has been used in the power and energy availability studies. The flushing discharge, as per the present practice, has not been considered (observations of CEA enclosed as ***ATTACH C***). The net 10-daily flows for power generation have been computed after deducting environmental releases from the natural river flows at the barrage site and the same are given in **Annexure 7.2** for 90% Dependable year and **Annexure 7.3** for 50% Dependable year respectively.

The power optimization studies have been carried out to arrive at the most effective and economical plant size consistent with the energy generation benefits has been presented in this chapter.

7.2. SCHEME LAYOUT

As mentioned above, the proposal consists of a barrage as the diversion structure. The discharges are diverted on the right bank by 2 nos. of feeder tunnels leading to 2 nos. underground desilting basins followed by a 1.30 km long head race tunnel carrying discharge to an underground power house through steel lined pressure shafts which are bifurcated near the power house. The power house cavity comprises of 3 nos. of units of 40.0 MW each. The water is discharged back into the Beas River through a short tail race tunnel. The gross head at this location is 357.83m. The diverted flows for power generation would be the assessed water available (Annexure 7.1) minus the environmental flows to be released from the gates. The unrestricted flows available for generation for 90% and 50% dependable years are given in Annexure 7.2 and Annexure 7.3 respectively.



Area Capacity Curve

7.3. PROPOSED OPERATION SCHEDULE

Sirkari Bhyol-Rupsiabagar plant is proposed to be operated purely as a run of the river plant as there is practically no live storage due to very steep and narrow valley (0.0409 MCM). Incoming discharges as coming into the reservoir will be fed into the water conductor system to run the power plant which will be operated for the whole day (24 hours). Since the live storage is very small, operating levels will fluctuate between FRL and MDDL during the period when the flows are less than the design discharge. However, during the period of surplus flows, the plant would operate at FRL.

7.4. TEN DAILY HYDROLOGICAL INFLOW SERIES

As mentioned above, 10-daily hydrological inflow series at the Sirkari Bhyol Barrge site from 1977-78 to 2014-15 has been considered as per **Annexure – 7.1**.

7.5. NET 10–DAILY FLOWS AVAILABLE FOR POWER GENERATION

The net 10 daily flows for power generation have been derived by deducting the mandatory environmental flows as per guidelines of MoEF to release from the barrage. Silt flushing discharge has not been considered. (observations of CEA enclosed as ***ATTACH C***).

7.6. COMPUTATION OF UNRESTRICTED ENERGY GENERATION

The computations of year wise unrestricted energy generation for all the years of data available are presented in **Annexure 7.4**.

7.7. DETERMINATION OF 90% AND 50% DEPENDABLE YEARS

The year wise unrestricted energy generation for 38 years has been arranged in reverse chronological order in **Annexure 7.5.**

The dependable year is calculated from the following formula:

$Y_p = (n + 1) \times P$

Where

Y_p = Dependable year with probability P

n = Number of years considered in the computation = 38 years

P = Probability of the flow being exceeded

$Y_{90\%}$= (38 + 1) x 0.9, Say 36th year

$Y_{50\%}$ = (38 + 1) x 0.5, 20th year

As per table of unrestricted energy in reverse chronological order, the 90% and 50% dependable years are 1987-88 and 2002-03 respectively.

7.8. EFFICIENCY OF TURBINE AND GENERATOR

Considering the head available for power generation, Francis turbine appears to be the suitable choice for the Project. The following efficiencies have been considered for the turbine and generator.

Efficiency of Francis Turbine	= 93.5 %
Efficiency of Generator	= 98.5 %
Combined efficiency (0.935×0.985)	= 0.9209, say= 92.10 %

7.9. HEAD FOR POWER GENERATION

(i) Gross Head

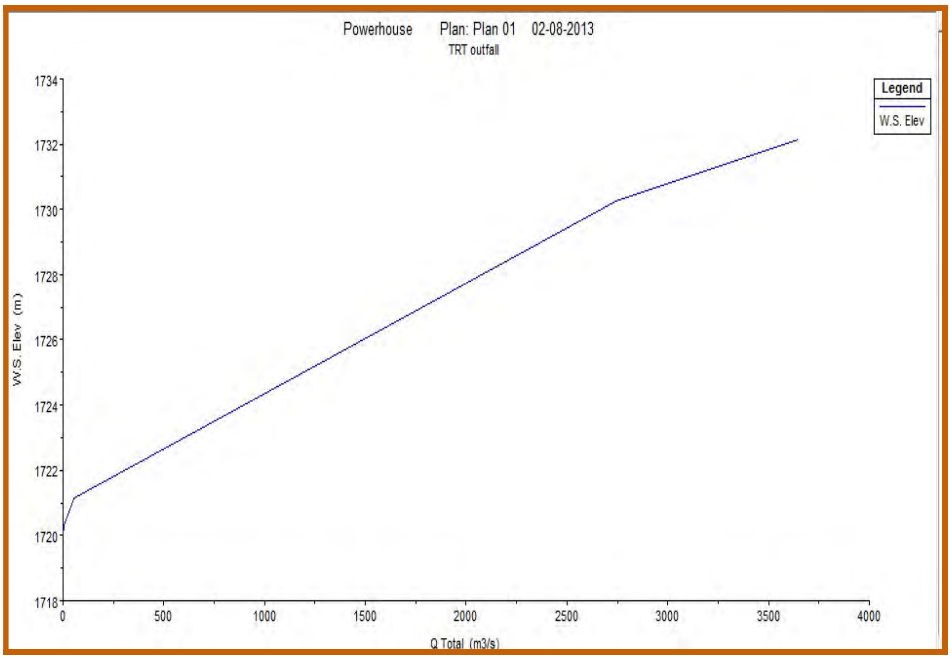
During the monsoon months, Sirkari Bhyol Power Station will run mostly on continuous basis and during the non monsoon months, the power station will run on partial capacity. The operating level in the reservoir has been considered as the average level of the reservoir throughout the year.

The gross head has been obtained from the difference of the operating level in the reservoir and the normal tail water level (TWL). For all the three units operating on full load and a corresponding design discharge of 37.83 m^3/sec in HRT, the tail water level at TRT outfall location is 1721.50 m. The gross head H_G has been determined as below:

Average reservoir level = MDDL+2/3 (FRL-MDDL) = 2079.33m

H_{Gross} = Operating level in the reservoir – TWL

H_{Gross} = (2078.0+2/3(2080-2078)) – 1721.50 = 357.83 m



Rating Curve at TRT outfall

(ii) Head Loss in Water Conductor System

The total head loss in water conductor system for four unit operation at full load has been worked out as 6.37m **(Annexure 7.10).** The station will run mostly on full load during monsoon season (June to September) when the discharges are usually surplus than the design discharge. The plant would utilize the available flows and run the station on partial capacity on continuous basis in a 24 hour cycle during non monsoon season. The number of units to be operated will depend on the inflow available during non-monsoon season such that one unit can run at full load or at least 55%-60% load.

Net Head: Available net head has been worked out by deducting head losses in the water conductor system from the gross head.

Net Head on turbine = $H_G - H_L$

(iii) Design Discharge, Q_D

Rated Net Head (main units) = MDDL+2/3 (FRL-MDDL) – TWL–Losses (all units running on full load)

= 2078 + 2/3× (2080 - 2078) -1721.50 –6.37

= 351.46 m

Design Discharge at Full Load for 3 units $Q_D = \frac{InstalledCapacity X 1000}{9.81 X \eta X Hnet}$ m^3/sec

$= \frac{120X1000}{9.81X0.921X351.46} = 37.83 m^3/s$

7.10. POWER POTENTIAL (MW)

The power potential has been calculated from the following formula:

$$P = \frac{Q \times H_{net} \times g \times \eta}{1000} \text{ MW}$$

Where,

P = Power generated in MW

Q = Discharge through turbines in m^3/sec

H_{net} = Net head on turbines in m

g = acceleration due to gravity 9.81 m/sec^2

η = overall efficiency of generating unit = 92.10 %

Assuming overall efficiency as 92%, the power generation is given by

$$P = \frac{0.921 \times 9.81 \times Q \times H_{net}}{1000} \text{ MW}$$

$$= \frac{9.035 \times Q \times H_{net}}{1000} \text{ MW}$$

7.11. ENERGY GENERATION (GWH)

The energy generated has been calculated by the following formula:

$$E = \frac{P \times T}{1000}$$

Where E = Energy generated in GWh

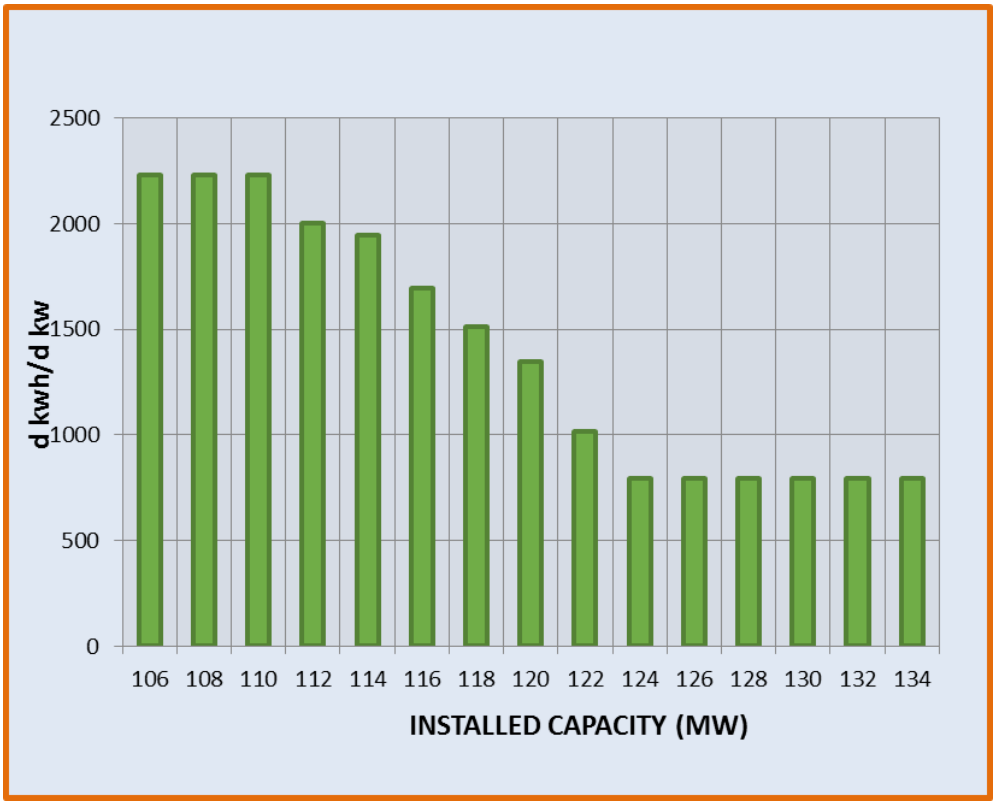
P = Power in MW

T = Period of generation in hours.

7.12. FIXING INSTALLED CAPACITY

One of the commonly used criterion for optimization of the installed capacity is based on the analysis of incremental energy that is generated with a unit increase in the installed capacity. Although this criterion does not use any economic or financial parameters, it gives a good idea about the "beneficial" installed capacity above which the incremental energy benefits are less attractive. A wide range of installed capacities have been studied using this criterion and the final installed capacity beyond which incremental energy benefits cease to be attractive is selected.

In this optimization study, energy generation with different installed capacities is analyzed. The energy computations are done for the 90% dependable year and 50% dependable year with the installed capacities increased in steps of 2 MW. Incremental Energy for different installed capacities has been tabulated in **Annexure- 7.6** for the 90% dependable year & **Annexure- 7.7** for 50% dependable respectively**.** The ratio of incremental energy per kW to incremental installed capacity (dkWh/dkW) for 90% dependable year is plotted against the installed capacities in the following figure from **Annexure- 7.9.**



A perusal of the results indicates the following:

A perusal of the graph indicates that for 2 MW increment in installed capacity, the ratio dkWh/dkW is approx. 1347.60 for installed capacity of 120 MW for 90% dependable flows. It can be seen from **Figure 7.1** that the incremental energy is constant upto installed capacity 110 MW, thereafter there is a sharp fall in the incremental energy after 110 MW for 90% dependable year upto 124 MW. From this it is concluded that the optimum installed lies within this range of 110-124 MW and accordingly CEA has recommended an installed capacity of 120 MW. The concurrence of CEA for the installed capacity is attached.

7.13. DISCUSSION

- The graphs of Potential utilised (%) vs Installed Capacity (MW) for 90% & 50% Dependable Years are shown in **Figure 7.2**

  It is observed that for 90% D.Y., 96.89% power potential is utilized with 120 MW installed capacity. In case of 50% D.Y., 82.44 % power potential is utilized with 120 MW installed capacity.

- The graphs of Annual Plant Load Factor (%) vs Installed Capacity (MW) for 90% & 50% Dependable Years are shown in **Figure 7.3**

  It is observed that in 90% Dependable Year, Plant Load Factor is 51.41% with 120 MW installed capacity. In case of 50% D.Y., Plant Load Factor is 62.90% with 120 MW installed capacity.

- The graphs of Annual Energy Generation (GWh) vs Installed Capacity (MW) for 90% & 50% Dependable Years are shown in **Figure 7.4**.

  It is observed that in 90% Dependable year the annual energy is 540.42 GWh with 120 MW installed capacity. In case of 50% D.Y. the energy available is 661.25 GWh with 120 MW installed capacity.

7.14. UNIT SIZE

For flexibility of operation and considering the average non-monsoon season discharge, it is proposed to provide the chosen capacity of 120 MW in three (3) units' configuration. This will ensure that at least one unit can operate at 55-60% load capacity during the period of lean discharge.

7.15. PEAKING ENERGY

As the project lies on a river which has a very steep gradient (1 in 10), it is not possible to achieve the peaking requirement of 3 hours in a 24 hour cycle with a low height

structure. Hence, the project has been planned as a purely run-of-the river scheme only. However, maximum possible generation during the peak demand period in the lean season shall be provided with the available pondage. The peaking hours available with 90% dependable year flows and average flows are given in **Annexure-7.8**. The pondage available between FRL and MDDL is 0.0409 million cubic meters (MCM). Therefore Sirkari Bhyol HEP is proposed to be planned as a purely ROR scheme.

7.16. FIRM POWER

The firm power is worked out on the basis of average discharge during the non-monsoon season (November to February) of 90% dependable year which is 7.49 m^3/sec. Therefore, Firm Power = 9.81 x 7.49 x 351.46 x 0.921 / 1000 = 23.78 MW.

7.17. SUMMARY

The various results / conclusions of the Power Potential Studies of Sirkari Bhyol Rupsiabagar HEP are summarized below.

S.NO.	PARAMETER	MAGNITUDE
(1)	Proposed installed capacity	120 MW (3 x 40 MW)
(2)	Proposed overload capacity	10% in each unit
(3)	Annual Energy Generation in 90% Dependable Year (1987-88) (100% Machine availability)	540.42 GWh
(4)	Design Energy Generation in 90% Dependable Year (1987-88) (95% Machine availability)	525.50 GWh
(5)	Annual Energy Generation in 50% Dependable Year (2002-03) (100% Machine availability)	661.25 GWh
(6)	Energy Generation in 50% Dependable Year (2002-03) (95% Machine availability)	643.97 GWh
(7)	d KWH/ d KW in 90% Dependable Year	1347.60
(8)	% Potential utilized in 90% dependable year	96.89%
(9)	% Potential utilized in 50% dependable year	82.44%
(10)	Annual Plant Load Factor in 90% Dependable year	51.41%
(11)	Annual Plant Load Factor in 50% Dependable	62.90%

	year	
(12)	Monsoon Load Factor in 90% Dependable year	84.89%
(13)	Monsoon Load Factor in 50% Dependable year	98.39%
(14)	Lean Period Plant Load Factor in 90% Dependable year (Nov-Feb)	19.69%
(15)	Lean Period Plant Load Factor in 50% Dependable year (Nov-Feb)	28.54%
(16)	Firm Power	23.78 MW

7.18. RECOMMENDATIONS OF CEA

The approved design parameters as per the recommendations of CEA (No 207/1/2014/HPA/846 dated 21st July,2017) are placed below.

S.NO.	PARAMETER	MAGNITUDE
(1)	Proposed installed capacity	120 MW (3 x 40 MW)
(2)	Unrestricted Annual Energy Generation in 90% dependable year	553.73 GWh
(3)	Annual Energy Generation in 90% Dependable Year (1987-88) (100% Machine availability)	537.52 GWh
(4)	Design Energy Generation in 90% Dependable Year (1987-88) (95% Machine availability)	529.12 GWh
(5)	Annual Plant Load Factor in 90% Dependable year	51.13%
(6)	Annual Plant Load Factor in 50% Dependable year	62.90%
(7)	Lean Period Plant Load Factor in 90% Dependable year (Nov-Feb)	19.83%

ANNEXURES

SMEC

ANNEX - 7.1 10-DAILY DISCHARGE DATA AT SIRKARI BHYOL BARRAGE SITE (JUNE 1977-MAY 2015)

State: Uttarakhand
Catchment area: 965.5 km²
Unit: Cumec

River : Goriganga
Distt. : Pithoragarh

Month	Days		1977-78 1	1978-79 2	1979-80 3	1980-81 4	1981-82 5	1982-83 6	1983-84 7	1984-85 8	1985-86 9	1986-87 10	1987-88 11	1988-89 12	1989-90 13	1990-91 14	1991-92 15	1992-93 16	1993-94 17	1994-95 18	1995-96 19	1996-97 20	1997-98 21	1998-99 22	1999-2000 23	2000-01 24	2001-02 25	2002-03 26	2003-04 27	2004-05 28	2005-06 29	2006-07 30	2007-08 31	2008-09 32	2009-10 33	2010-11 34	2011-12 35	2012-13 36	2013-14 37	2014-15 38	Average
June	10	I	63.8	58	42.2	44.3	48.7	52.4	57.8	76.8	42.3	46.8	57.5	55.4	51.4	64.3	59.4	52.4	52	67	80.2	51.3	49.2	56.5	42.2	70	49.9	52	58.9	42.2	42.2	59	56.2	47.9	44.1	42.2	42.8	48.4	56.1	48	52.7
	10	II	42.2	98.2	43.2	45.1	48.8	67.9	48.7	88.1	44.8	46.2	151.5	46.1	50.1	61.2	77.8	75.5	56	66.6	54.2	61.2	45	51.7	55.4	66.7	57.3	57.7	59.4	56.5	49.4	48.8	71.8	89	42.2	42.2	55.7	47.1	101.9	80.9	37.6
	10	III	55.2	68.7	48	49.6	70.4	62.8	64.7	77.5	54.4	80	51.9	62.8	60.6	55.5	77.3	76	59.4	63	62.8	71.3	57	78.3	57.8	71.6	64.4	67.2	65	59.6	66.4	56.3	73.1	72.6	54.8	46.3	78.4	61.2	112.4	92	65.9
July	10	I	59.8	58.4	53.1	58	68.1	60.2	58.5	69.5	47.5	66.1	41.7	52.3	47.8	47.5	69.1	45.7	64.7	64.6	54.8	57.3	58	75	72.5	62.5	56.2	69.8	68.7	52.4	77.9	62.8	82	65.1	53.7	45.1	85.1	64.1	121.3	69.8	74.3
	10	II	59.2	85.5	85.7	41.5	62.4	67.2	50.5	53.4	67.4	78.1	43.2	62.1	65	62.7	73.3	67.5	66.4	61.9	71.1	75.2	68.7	72.2	67.5	77.6	66.6	63.9	76.7	57	67.4	60.2	78.7	68.6	55.8	68.6	71.4	51.5	130	95.6	68.3
	11	III	70.5	68.8	49.6	48.4	97.4	66.9	69.4	69.4	73.2	83.2	58.9	69.2	69.8	57.4	85.2	68	68.1	91.6	75	72.2	75.9	86.4	105.7	82.5	112.1	69.6	89.2	79.5	94.8	97.2	108.7	100.5	84.1	98.5	112	96.7	146	96.9	83.9
August	10	I	67.3	76.1	63.1	63.6	88.4	82.1	73	58.7	65.1	66.9	68.6	94	91.2	49	77.2	73.2	84.8	68.7	92.5	90.2	91.3	97.5	91.2	91.6	91.6	71.1	82.5	92.1	89.1	79.4	92.3	98.3	68.9	93.6	87.7	96	116.9	113.9	78.2
	10	II	75.4	98.6	93.2	98.7	86.6	89.6	91	89.2	96.5	98.7	93.9	88.5	80.6	89	78	76.6	88.8	88.5	93.1	73.8	85.2	94.5	78.5	78.1	90.6	88.7	94	87.8	89.4	78.9	90.9	73.6	88.3	101.7	103.6	96.2	125.4	105.7	77.3
	11	III	94.2	88.6	87.4	91.6	72.4	90.1	90.9	94.4	90.6	98.5	96.8	97.2	108.1	89.4	85.6	93.5	99.9	90.3	98.5	89.3	86	82.4	93.6	94.3	96.3	73.2	86.7	76.8	94.4	113	95.7	79.3	83.5	111.7	103.5	94.6	114	91.2	77.8
Sept	10	I	49.7	57.1	79.9	39.6	43.4	58.3	79	57.3	69.2	59.6	48.2	58.2	80.7	71.7	62.9	72.6	70.7	64.7	100.1	68.8	63	56	59.2	63.1	62.7	79.3	79.5	54	62.9	73.4	90	51.6	69.5	110.3	78.5	68.4	86.6	78.7	64.6
	10	II	48.6	45.9	53.1	52.4	56.1	48.1	67	43.6	48.4	54.4	57	57.7	59.5	57	51	58.6	68.3	48	56.6	50.9	60.4	64.5	58.2	48.6	41	74.1	63	48.3	70	68.5	64.4	47.6	67.9	69.4	70.1	60.9	65.6	68.6	53.9
	10	III	41.4	37.3	21	33.2	39.4	31.9	58.4	29	37.1	17.9	28.7	44.3	46.5	45.2	36.4	44.8	47.9	37.1	42.6	41.1	40.2	47.2	51.3	39.7	39.6	44.5	51.3	45.1	75.6	47.8	63.1	53.2	42.8	75.2	42.2	47.9	56.4	25.9	43.9
Monsoon			575.3	619.4	393.2	438.3	684.2	705.0	689.2	650.8	627.5	598.8	498.2	552.6	736.5	628.7	734.3	729.9	653.9	715.6	755.7	654.2	635.5	740.3	702.0	724.4	694.3	695.3	767.8	640.6	728.8	770.0	869.3	719.7	590.3	836.1	838.8	746.0	1082.9	1254.0	700.9
Monsoon			595.8	641.6	407.3	454.0	708.7	730.2	713.9	674.1	649.9	620.2	516.0	572.4	762.8	651.2	760.5	756.0	673.2	741.1	782.7	677.6	658.3	766.8	727.1	750.2	719.1	720.2	795.3	663.5	754.8	797.6	900.4	743.4	611.3	865.2	868.0	772.7	1121.6	1298.8	726.0
Oct.	10	I	20.6	30.3	21	26.6	29.9	26.2	30.4	26.9	30.7	13.7	16.7	24.9	34.5	33.7	37.9	34.1	36.9	30.6	35.2	36.1	29.1	36	40.8	32.6	29.6	36	36.9	30.6	40.3	36.2	40.4	37.1	32.6	47.1	33.8	34	51.3	30	34.9
	10	II	28.2	26.7	20.3	24.6	23.5	22.8	31.9	20.9	42.1	33	15.6	17.9	30.4	26	30.5	30.7	39.4	27.1	31.2	28	26.2	41.3	31.4	28.1	27.9	30.4	32.3	34.3	48	33.6	41.9	31.1	38.2	32	29.7	29.1	46.4	17.5	29.3
	11	III	26	25.4	26.6	25	26.3	28.7	28.8	25.1	27.9	11.8	14.7	15.4	28	22.5	27.7	27.9	29.8	27.9	29.3	28	27.2	36.2	36.3	28.3	29.6	28.4	22.5	30	45.2	32.1	39.6	30.7	30.8	32.5	29.5	31.9	46.9	17.3	29.3
Nov.	10	I	20.6	13.8	7.3	17.3	16.5	11.9	19.2	13.9	20.4	10.1	11.1	13.6	20.5	16.3	22.4	23.5	24.8	12.3	18.8	19.2	17.3	27.5	19.7	20.1	24.1	16.2	20.1	20.4	47.5	25.9	38.1	21.2	19.6	23.4	22.7	23.4	56.3	14.0	20.9
	10	II	15.5	11.3	6.4	14	12	11	16.8	15	16	9	9.6	12.1	19.1	17.2	19.6	20.9	24	10.8	17.6	15.9	15.6	21.9	16.3	15.4	21.3	15.2	16	17.6	58.7	23.4	35.4	19.2	19.2	19.1	21.8	19.4	51.6	11.2	18.6
	10	III	12.7	9.8	5.7	11.4	9.4	8.2	12.8	12.7	12.3	8.6	8.6	10.4	17.7	15.2	16.4	17.6	23.6	9.2	14.8	12.6	14.2	16.3	15.3	12.5	19.6	12.5	16.7	16.2	39.6	14.3	29.2	15.7	16.7	14.7	18.7	17.5	45.1	10.4	15.7
Dec.	10	I	10.8	7.6	5.4	9.8	8.5	6.8	11.8	11.9	10.4	9.1	8.7	9.1	14.9	13.6	13.9	16.8	17.4	10.7	12.4	11.2	14.5	15.4	14.6	11.7	17.6	12.2	14.9	15.3	13.2	12.2	27.4	13.8	14.9	12.9	17.9	14.7	34.2	9.6	13.2
	10	II	9.4	6.9	5	8	7.6	6.1	11.1	11.4	9.4	8.6	8.2	8.4	13.9	12.1	13.5	15	12.6	9.2	11.4	10.3	14.7	14.2	12.6	10.5	13.6	11.3	13.3	14.6	12.1	11.7	22.7	12.1	13.1	12	16.4	14.1	32.9	9.3	11.4
	11	III	10	6.2	4.9	8.1	9.2	6.2	10.8	11.2	9.5	8.4	8.6	9.3	14.6	12.8	14.8	15	13.2	9.1	11.8	10.6	13.8	13.5	13.7	11.1	12.2	11.4	14	15.1	13.6	13.8	20	12.7	13.1	12.5	14.1	12.7	13.3	9.6	11.4
Jan.	10	I	10.7	7.3	7.1	9.7	9.4	7.9	10.6	12.3	10.7	9.6	9.6	10	13.5	14.7	14.9	12.4	14.5	9.6	12.4	11.6	14.3	13.4	13.6	12.3	12.6	12.5	14.9	11.7	11.9	11.4	17.1	13.6	13.4	13.6	14.1	12.9	14.3	12.7	12.1
	10	II	10.4	7	6.6	9.1	9	8.7	9.6	11.9	10.1	9.6	9.3	11.3	13	12.6	13.5	11.9	14.8	9.7	12.7	11.2	12.6	12.3	13.1	11.6	12.6	12.2	12	10.7	12.9	11.2	15.1	12.9	13.4	12.6	13.5	12.1	14	10	11.6
	11	III	10.7	7.5	7.5	10.6	9.5	10	9.6	12.9	10.7	10.1	9.3	11	14.1	13.6	15.2	12.1	15.4	10	13.9	11.7	13.5	12.1	13.4	12.1	14.9	13.2	12.3	11.5	12.9	11.9	15.8	13.3	13.7	13.4	14.8	14.2	14.9	13.1	12.7
Feb.	10	I	9.1	8.9	9.6	9.6	8.5	9.8	9.4	11.4	9.8	9.1	8.5	8.9	11	12.1	14.1	11.7	13.5	9.1	12.2	9.1	11.1	11.5	13.4	11	9.9	11.6	10.7	10.7	12.3	10.8	14.5	11.6	12.2	12.1	13.4	10.8	13.4	12.1	11.0
	10	II	9	8.8	8.8	8.5	9.2	8.5	9	11.7	10.1	9.4	8.7	8.7	11.5	13.5	12.9	10.7	13.1	10.1	11.8	10.7	11.4	11.4	12.6	10.8	11.8	11.9	10.5	11.8	12.8	11.3	14	11.5	11.7	12.5	11.1	14.2	13.5	10	11.2
	9	III	8.3	8.5	8.5	7.6	7.4	6.8	8.8	8.8	8	7.1	8.4	7.2	8.9	10.5	10.3	9.3	10.5	7.4	11.7	8.8	9.5	9.3	10.9	8.4	8.2	10	9.5	8.3	10.1	8.8	12.8	9.8	9.8	10	10.1	11.2	10.7	10	9.2
Mar.	10	I	11.9	9.5	10.8	10.8	10.7	9.4	12.2	13.4	10.8	10.1	10.4	10.4	12.6	27.5	13.9	11.9	16.1	11.7	13.5	12.8	13.7	11.1	21.6	14.2	11.3	15	12.6	12.9	32.5	10.3	15	12.9	12.8	14.1	14.2	13.1	13.1
	10	II	13.9	9.5	10.6	10.3	12.2	10.9	13.1	13.8	11.1	10.9	11	10.9	14.2	29.3	14.4	17.5	14.3	10	17	11.4	13.4	11.8	14.2	11.3	20	13.6	11.6	14.7	13.3	19.2	29.3	19.4	12	13.9	12.7	17.6	15	13.3	13.9
	11	III	14.1	10	11.9	14.2	13.6	14.8	16.1	16.6	13.1	12.8	17.5	13.6	17	35.6	18.8	21.5	16.3	14.7	30.8	13.5	17.3	14	16.1	13.4	24.1	16	14.6	16.1	14	23.7	19.6	11.9	15.9	17.8	13.4	24	17.2	14.9	16.8
Apr.	10	I	17.1	16.7	16.7	17.3	20.3	17.2	17	17.5	16.7	16.7	21	16.8	19.4	44.9	20.3	20.6	21.7	17.3	34.1	17.4	24.6	17.8	24.9	18.1	25.6	22.5	16.7	17.3	17.3	27.7	19.8	16.7	19.6	19.2	17	24.4	21.4	18	20.2
	10	II	29.6	16.7	19.5	25	26	19.5	19.3	21.3	22.7	16.7	27.5	18.6	24	35.9	23.6	30.6	20.1	19.8	30.2	19.2	26.4	23.6	30.3	18.7	26.4	31	18.7	19.9	17.7	37.6	21.2	17	24.2	20.9	23.1	26.8	21.3	21.4	23.8
	11	III	27.5	18.7	24.1	29.6	23.6	20.9	22	24.1	27.2	19.6	30.7	19.5	26.4	31	25.6	41.6	23.9	25	33.6	25.5	31.2	42	31.5	33.2	38.6	36.1	24.3	22.6	21.5	31.2	40.2	19.6	22.3	22.1	28.2	29.2	29.4	29.2	27.0
May	10	I	45.9	24.4	30.2	33.2	39.7	40.9	31.5	31.9	38.8	24.4	37.3	24.4	34.6	43.2	33	57	34.7	31.1	45.4	29	46.1	33.7	43.7	30.4	43.9	36.9	26.1	30.1	36.3	40.3	36.7	34.8	28.5	33.3	30.8	31.9	31.1	37.4	36.4
	10	II	38.6	28.6	31.8	28.6	36.1	36.1	40.3	32.9	41.6	24.4	44.8	29.6	35.1	46.7	33.6	46.7	37.8	72	36.1	25.8	46.7	30.1	57.6	49	60.1	43.2	34.8	29.5	49.6	69.6	38.8	29.6	28.5	36.1	37.1	31.6	59.6	41.7	42.2
	11	III	60.1	26.6	28.6	48.4	41.9	35.5	37	48.9	44.8	30.6	52.6	48.1	57.8	48.6	45.4	68.2	59.8	49.2	59.3	36.1	76.3	47.5	76.8	42	89.7	59.4	39.9	31.5	69.8	47	41.3	35.4	31.2	45.8	43.2	54.5	61.5	48.5	49.1
Non-monsoon (MCM)			442.3	297.3	284.6	375.9	375.9	368.1	415.9	383.5	407.2	276.8	370.6	338.9	465.8	553.4	465.6	504.9	483.7	398.5	467.0	369.6	483.2	458.3	525.0	404.6	526.5	454.1	411.8	409.0	507.1	482.6	567.6	382.4	426.1	437.8	436.5	469.7	635.0	375.4	434.7
Non-monsoon (mm)			458.1	307.9	294.7	389.4	389.3	381.3	430.7	397.2	421.7	286.7	383.9	351.0	482.4	573.2	482.2	522.9	500.9	412.8	483.7	382.8	500.5	474.7	543.8	419.1	547.4	470.3	426.5	423.7	587.3	499.9	587.9	396.1	441.4	453.4	452.1	486.3	678.4	388.8	450.3
Annual (MCM)			1017.6	916.7	677.8	814.3	1060.1	1073.2	1105.1	1034.3	1034.7	875.6	868.9	891.5	1202.2	1182.1	1199.9	1234.8	1135.5	1114.1	1222.7	1023.8	1118.8	1198.7	1227.1	1129.0	1222.8	1149.4	1179.7	1089.6	1295.8	1252.7	1436.9	1102.1	1016.4	1253.9	1255.3	1215.8	1758.0	1629.4	1135.7
Annual (mm)			1054.0	949.5	702.0	843.4	1097.9	1111.5	1144.6	1071.3	1071.6	906.8	899.9	923.4	1245.2	1224.4	1242.7	1278.9	1176.1	1153.9	1266.4	1060.4	1158.7	1241.5	1270.9	1169.3	1266.5	1190.5	1221.8	1087.2	1342.1	1297.4	1488.3	1141.5	1052.7	1298.7	1300.1	1259.2	1800.1	1687.6	1176.2

SMEC

ANNEXURE -7.2 COMPUTATION OF UNRESTRICTED FLOW AVAILABLE FOR POWER GENERATION IN 90% DEPENDABLE YEAR (1987-88)

Design Discharge = 37.79 cumecs

Month	Days		River inflow (cumec)	Flushing Discharge (Cumec)	Environmental Releases (Cumec)	Total Spill from Gates (Cumecs)	Unrestricted flow available for generation (Cumecs)
June	10	I	50.50	0.00	14.13	14.13	36.37
	10	II	51.50	0.00	14.13	14.13	37.37
	10	III	51.90	0.00	14.13	14.13	37.77
July	10	I	41.70	0.00	14.13	14.13	27.57
	10	II	43.20	0.00	14.13	14.13	29.07
	11	III	58.80	0.00	14.13	21.01	44.67
August	10	I	48.80	0.00	14.13	14.13	34.67
	10	II	49.90	0.00	14.13	14.13	35.77
	11	III	56.80	0.00	14.13	19.01	42.67
Sept	10	I	46.30	0.00	14.13	14.13	32.17
	10	II	37.00	0.00	14.13	14.13	22.87
	10	III	28.70	0.00	14.13	14.13	14.57
Oct	10	I	18.70	0.00	6.42	6.42	12.28
	10	II	15.60	0.00	6.42	6.42	9.18
	11	III	14.70	0.00	6.42	6.42	8.28
Nov	10	I	11.10	0.00	1.87	1.87	9.23
	10	II	9.60	0.00	1.87	1.87	7.73
	10	III	9.60	0.00	1.87	1.87	7.73
Dec	10	I	8.70	0.00	1.87	1.87	6.83
	10	II	8.20	0.00	1.87	1.87	6.33
	11	III	8.80	0.00	1.87	1.87	6.93
Jan	10	I	10.00	0.00	1.87	1.87	8.13
	10	II	9.30	0.00	1.87	1.87	7.43
	11	III	9.30	0.00	1.87	1.87	7.43
Feb	10	I	9.50	0.00	1.87	1.87	7.63
	10	II	9.70	0.00	1.87	1.87	7.83
	8	III	8.60	0.00	1.87	1.87	6.73
Mar	10	I	10.60	0.00	6.42	6.42	4.18
	10	II	17.00	0.00	6.42	6.42	10.58
	11	III	17.50	0.00	6.42	6.42	11.08
Apr	10	I	21.00	0.00	6.42	6.42	14.58
	10	II	27.50	0.00	6.42	6.42	21.08
	10	III	30.70	0.00	6.42	6.42	24.28
May	10	I	37.30	0.00	6.42	6.42	30.88
	10	II	44.80	0.00	6.42	7.01	38.38
	11	III	52.60	0.00	6.42	14.81	46.18

SMEC

ANNEXURE -7.3 COMPUTATION OF UNRESTRICTED FLOW AVAILABLE FOR POWER GENERATION IN 50% DEPENDABLE YEAR (2002-03)

Design Discharge = 37.79 cumecs

Month	Days		River Inflow (cumec)	Flushing Discharge (Cumec)	Environmental Releases (Cumec)	Total Spill from Gates (Cumecs)	Unrestricted flow available for generation (Cumecs)
June	10	I	52.00	0.00	14.13	14.21	37.87
	10	II	57.70	0.00	14.13	19.91	43.57
	10	III	67.20	0.00	14.13	29.41	53.07
July	10	I	69.80	0.00	14.13	32.01	55.67
	10	II	63.30	0.00	14.13	25.51	49.17
	11	III	69.60	0.00	14.13	31.81	55.47
August	10	I	71.10	0.00	14.13	33.31	56.97
	10	II	68.70	0.00	14.13	30.91	54.57
	11	III	73.20	0.00	14.13	35.41	59.07
Sept	10	I	79.30	0.00	14.13	41.51	65.17
	10	II	74.10	0.00	14.13	36.31	59.97
	10	III	44.50	0.00	14.13	14.13	30.37
Oct	10	I	36.00	0.00	6.42	6.42	29.58
	10	II	30.40	0.00	6.42	6.42	23.98
	11	III	28.40	0.00	6.42	6.42	21.98
Nov	10	I	18.20	0.00	1.87	1.87	16.33
	10	II	15.20	0.00	1.87	1.87	13.33
	10	III	12.90	0.00	1.87	1.87	11.03
Dec	10	I	12.20	0.00	1.87	1.87	10.33
	10	II	11.30	0.00	1.87	1.87	9.43
	11	III	11.60	0.00	1.87	1.87	9.73
Jan	10	I	12.50	0.00	1.87	1.87	10.63
	10	II	12.20	0.00	1.87	1.87	10.33
	11	III	13.20	0.00	1.87	1.87	11.33
Feb	10	I	11.60	0.00	1.87	1.87	9.73
	10	II	11.60	0.00	1.87	1.87	9.73
	8	III	10.00	0.00	1.87	1.87	8.13
Mar	10	I	14.20	0.00	6.42	6.42	7.78
	10	II	13.60	0.00	6.42	6.42	7.18
	11	III	18.00	0.00	6.42	6.42	11.58
Apr	10	I	22.50	0.00	6.42	6.42	16.08
	10	II	31.00	0.00	6.42	6.42	24.58
	10	III	36.10	0.00	6.42	6.42	29.68
May	10	I	35.80	0.00	6.42	6.42	29.38
	10	II	43.20	0.00	6.42	6.42	36.78
	11	III	53.40	0.00	6.42	15.61	46.98

SMEC

Annexure - 7.4 Unrestricted Energy (GWh) at Sirkari Bhyol Barrage Site 1977-78 to 2014-15

Months			77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
June	I	10.0	35.3	44.2	30.2	33.8	37.9	39.9	43.9	60.1	62.2	35.7	58.5	1.7	39.2	49.0	45.3	38.4	39.6	51.1	61.1	39.0	33.0	43.1	32.2	59.4	38.0	39.6	44.9	32.2	30.2	44.2	42.8	36.5	33.8	32.3	32.5	36.9	42.8	36.8
	II	10.0	32.2	44.8	32.2	34.4	37.8	51.3	37.1	60.3	54.1	58.5	39.2	35.1	38.2	48.7	59.3	57.5	42.7	50.8	48.9	48.6	34.3	39.4	42.4	56.8	43.7	44.0	45.3	38.8	37.8	37.5	54.7	60.2	32.2	32.2	43.2	35.9	77.7	38.8
	III	10.0	42.1	53.1	36.6	37.8	53.7	48.6	49.3	59.1	41.5	63.3	39.6	47.9	46.2	40.8	59.9	57.9	45.3	70.9	47.9	54.5	43.4	60.4	44.1	54.6	48.1	51.2	49.5	38.8	2.1	42.9	55.7	55.3	41.6	36.3	59.7	46.7	65.7	38.1
July	I	10.0	43.3	44.5	35.2	39.7	51.9	45.9	42.5	53.0	36.5	50.8	31.6	39.9	36.4	36.2	50.6	34.8	34.1	49.2	41.6	28.9	38.1	53.3	50.3	47.6	42.8	53.2	50.1	39.9	59.4	63.1	62.5	49.6	25.7	34.4	64.9	48.9	92.3	464.1
	II	10.0	45.1	42.6	37.2	31.6	52.8	51.2	38.5	40.7	51.4	59.7	32.9	47.3	52.6	46.5	55.9	51.5	50.6	47.2	54.2	55.8	50.1	55.0	51.7	59.3	66.0	48.2	58.5	43.4	66.8	61.1	58.5	52.3	42.5	52.3	54.4	39.6	99.1	72.9
	III	11.0	59.4	56.1	41.6	48.6	77.6	72.8	58.2	58.2	61.4	69.8	49.3	76.5	77.0	66.1	71.4	72.1	54.6	68.4	62.9	61.4	67.0	74.1	65.3	69.2	94.0	58.3	74.8	66.6	79.6	81.7	89.4	88.3	53.7	80.9	85.9	79.4	122.4	91.2
August	I	10.0	47.1	53.9	33.3	37.5	67.4	62.6	50.8	44.5	49.6	51.0	37.2	56.4	61.9	37.3	58.8	60.4	64.7	52.4	70.5	54.0	69.6	74.2	62.3	62.3	62.3	54.2	62.9	68.5	75.5	59.7	70.3	68.6	50.2	71.5	66.8	79.2	89.1	86.8
	II	10.0	57.5	44.9	30.6	29.5	66.2	68.1	61.7	45.1	65.8	44.7	39.0	52.6	61.4	65.5	59.4	56.6	53.2	63.0	55.7	56.2	53.5	71.9	56.3	59.5	61.6	52.4	56.4	66.9	68.3	54.0	71.6	66.1	60.5	77.5	76.9	65.7	91.8	60.6
	III	11.0	45.6	55.8	31.4	35.1	60.7	75.5	67.6	54.0	70.1	41.0	47.6	48.0	50.6	49.8	71.6	78.2	50.2	75.7	71.7	59.1	46.9	69.1	68.6	62.3	55.6	61.4	62.7	64.5	62.4	94.7	60.2	65.6	53.2	93.6	66.8	79.3	95.6	76.5
Sept	I	10.0	34.8	43.5	22.8	29.4	33.1	44.9	60.2	44.0	45.9	29.6	36.3	26.8	65.3	54.6	47.9	55.3	59.9	49.3	76.3	62.4	48.0	42.7	41.1	98.1	40.2	60.4	60.6	41.2	47.9	54.4	68.6	39.5	53.0	68.5	57.5	52.1	66.0	58.5
	II	10.0	35.5	35.0	17.6	24.7	26.8	38.7	51.1	33.4	36.3	18.6	28.2	21.1	45.3	43.4	38.9	44.9	49.8	35.1	63.1	36.8	46.9	33.9	42.1	85.5	31.2	56.5	48.0	35.3	53.3	49.8	49.1	36.3	51.7	68.1	53.4	63.9	59.0	52.4
	III	10.0	31.6	28.4	16.0	23.0	27.7	24.3	44.5	22.1	29.3	13.6	21.9	39.9	35.5	34.4	29.3	34.1	36.4	28.3	32.5	31.3	30.6	36.0	39.1	39.3	27.9	33.9	43.7	34.4	57.0	36.9	63.3	40.5	32.6	57.4	32.2	36.5	43.0	19.7
Oct	I	10.0	25.0	23.1	16.0	20.4	22.8	20.0	30.0	19.3	23.4	16.4	14.3	18.0	26.3	25.7	28.9	26.0	28.1	23.3	26.6	27.5	22.2	29.0	31.2	25.0	22.7	27.4	30.1	30.3	45.9	27.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	II	10.0	21.5	20.3	15.5	18.7	19.4	17.4	24.3	15.9	32.1	9.9	11.9	13.6	23.2	19.6	23.2	23.4	26.2	20.7	23.6	21.3	20.0	31.5	23.9	21.4	21.3	23.2	24.6	29.6	39.6	24.1	862.5	585.5	449.8	621.3	634.6	568.5	625.3	955.7
	III	11.0	23.8	21.9	17.3	23.6	22.0	19.9	24.6	18.5	23.1	9.9	12.3	15.4	23.6	19.9	23.2	23.4	25.1	23.1	24.6	23.5	22.6	30.3	25.4	23.7	24.6	23.6	27.2	29.1	37.9	26.9	754.8	624.9	512.5	708.6	715.9	647.7	940.3	1080.8
Nov	I	10.0	15.2	9.6	5.6	13.1	12.6	9.1	14.6	10.6	15.5	7.7	8.5	10.4	15.6	13.9	16.8	17.6	18.9	9.4	14.3	14.6	13.2	21.0	15.0	15.3	18.4	13.9	15.3	15.5	38.2	19.7	46.0	28.3	40.1	31.6	25.8	25.9	39.1	15.2
	II	10.0	11.6	8.6	4.9	10.7	9.1	8.4	12.8	9.9	12.2	6.5	7.3	9.2	14.6	13.1	14.3	15.9	16.3	8.2	13.4	12.0	11.9	16.7	13.9	11.7	16.2	11.6	14.5	13.6	40.9	18.2	31.9	23.7	27.6	24.4	22.6	22.2	34.6	13.3
	III	10.0	9.7	7.5	4.3	8.7	7.2	6.2	10.5	9.7	9.4	6.8	7.3	7.9	13.5	11.6	12.5	13.3	15.7	7.1	11.3	9.8	10.8	13.9	12.1	9.5	15.1	9.6	12.7	12.3	29.6	10.9	30.3	22.9	25.5	24.8	22.5	24.3	37.3	13.2
Dec	I	10.0	8.2	5.8	4.1	8.7	6.5	5.2	9.0	9.1	7.9	6.9	6.6	6.9	11.4	10.5	10.6	9.2	13.5	8.2	9.5	8.5	11.1	11.9	11.1	8.9	13.3	9.3	11.3	11.7	10.1	9.3	29.0	16.2	15.1	17.8	17.3	17.8	42.9	10.7
	II	10.0	7.2	5.0	3.8	8.1	5.9	4.6	8.5	8.7	7.2	6.3	6.2	6.4	10.6	9.2	10.3	8.9	11.3	7.6	8.8	7.8	11.2	10.8	9.8	8.0	10.4	8.6	10.1	11.3	9.2	8.9	27.0	13.8	13.8	14.6	16.7	14.8	39.5	9.5
	III	11.0	8.4	5.2	4.1	6.8	8.9	5.3	9.1	9.4	8.0	7.9	7.4	7.8	12.2	10.7	12.4	7.8	12.0	7.6	9.9	8.9	11.6	11.3	11.5	9.3	10.2	9.7	11.7	13.2	8.9	9.1	24.6	13.2	14.0	12.3	15.7	14.5	37.8	8.7
Jan	I	10.0	8.2	5.6	5.4	7.4	7.2	6.0	8.1	10.1	8.2	7.3	7.5	7.6	10.3	11.2	11.4	9.5	11.1	7.2	9.5	8.8	10.9	10.2	10.5	9.4	9.8	9.5	10.8	8.9	9.1	8.7	20.9	10.5	11.4	9.8	13.6	11.2	26.1	7.5
	II	10.0	7.9	5.3	5.0	6.8	8.3	5.6	7.5	9.1	7.7	7.0	7.1	8.6	8.9	9.6	10.3	8.1	11.3	7.4	9.7	8.5	9.8	8.4	10.0	8.0	9.8	9.3	9.1	8.2	9.8	8.5	17.3	9.2	10.0	9.1	11.0	10.7	9.8	7.1
	III	11.0	9.0	6.1	6.1	8.9	8.0	8.4	8.6	10.7	9.6	8.5	7.8	9.2	11.8	11.4	12.7	10.1	12.9	9.4	11.7	9.1	10.2	10.8	11.6	10.3	12.0	11.1	10.3	9.7	11.7	9.9	16.8	10.6	11.6	10.5	11.8	10.6	11.1	9.2
Feb	I	10.0	6.9	5.2	5.2	7.3	7.0	6.7	6.4	8.7	7.5	6.9	7.2	6.8	9.4	9.2	10.7	8.9	10.3	6.9	9.3	6.9	9.5	8.6	10.2	8.4	7.5	8.6	9.2	8.2	9.4	8.2	13.0	10.4	10.2	10.4	10.7	9.6	10.9	9.4
	II	10.0	6.9	5.2	5.2	7.2	7.0	6.5	6.8	8.9	7.7	7.2	7.4	6.6	9.0	10.3	9.2	12.7	10.0	7.7	9.0	8.2	8.6	8.7	9.6	8.5	8.7	8.6	9.0	9.0	9.5	8.6	11.8	9.8	10.2	9.6	10.3	10.0	10.7	9.1
	III	8.0	5.0	3.4	5.2	4.6	4.3	4.0	5.4	6.0	4.9	4.7	5.2	4.4	5.4	6.4	6.3	5.7	6.4	4.8	7.1	5.2	5.6	5.7	6.5	6.1	5.6	6.1	5.8	5.7	6.2	5.4	9.6	8.1	8.4	8.2	8.7	8.7	9.1	8.0
Mar	I	10.0	9.0	6.5	6.2	8.2	8.2	7.3	9.3	10.4	8.2	7.7	8.1	8.1	9.6	21.0	10.3	13.6	9.0	7.7	9.6	8.9	10.3	9.6	10.4	9.5	16.5	10.6	9.6	9.9	9.6	9.6	11.1	8.8	9.3	9.2	9.5	12.1	10.2	9.2
	II	10.0	10.6	6.5	9.1	7.6	9.3	9.3	10.0	10.5	9.5	8.3	13.0	8.3	10.8	22.3	11.3	13.3	10.5	7.6	13.0	8.7	10.2	9.1	10.8	8.6	15.2	10.4	8.8	11.2	10.1	12.6	10.7	8.6	8.9	9.5	8.5	10.8	10.1	9.1
	III	11.0	11.8	8.4	11.7	11.9	13.8	12.2	15.2	13.9	11.0	10.8	14.7	11.4	14.3	29.8	15.8	18.0	13.8	12.3	17.4	11.7	14.5	11.7	15.2	11.2	20.2	15.1	12.4	13.2	11.7	13.9	10.8	6.5	9.2	8.4	8.5	9.4	9.0	8.4
Apr	I	10.0	13.0	12.7	12.7	13.1	17.0	13.1	13.0	13.8	12.7	12.7	16.0	12.8	14.0	34.2	15.5	17.2	16.5	13.2	18.4	13.3	18.7	13.6	19.0	13.8	19.7	17.1	12.7	13.3	13.2	21.1	17.1	7.8	9.9	9.5	9.8	10.7	10.8	10.0
	II	10.0	21.8	12.7	14.9	13.1	18.9	14.9	14.7	16.2	18.1	13.7	21.0	14.2	18.2	49.3	17.9	23.3	15.4	15.1	23.2	14.6	20.1	17.2	23.1	15.0	21.6	23.6	12.7	14.4	13.5	28.7	16.8	7.9	9.9	10.1	8.7	13.4	11.4	10.1
	III	10.0	21.8	15.0	19.4	20.3	20.4	15.7	16.8	18.4	20.7	15.1	23.4	14.9	23.2	23.6	21.8	31.7	16.5	19.1	25.6	17.9	28.4	24.4	28.6	17.7	25.8	27.5	18.5	17.4	16.4	23.9	12.7	9.1	12.0	13.6	11.0	18.3	13.1	11.4
May	I	10.0	15.0	18.6	23.0	25.7	29.1	31.2	24.0	24.3	26.0	18.6	28.4	18.6	26.4	32.9	28.2	43.4	26.4	29.7	34.6	21.3	36.7	25.7	33.3	29.3	33.5	27.3	20.3	22.9	27.6	30.7	14.3	12.7	14.2	13.9	15.0	18.6	16.3	13.7
	II	10.0	43.3	22.0	23.9	29.6	27.5	41.2	30.9	29.1	31.7	19.6	34.1	30.4	40.5	37.1	38.6	28.6	28.8	54.9	29.0	19.5	35.6	22.9	43.9	33.5	61.5	32.9	26.5	22.5	38.0	35.5	16.2	13.0	19.4	15.9	17.6	20.4	16.2	16.3
	III	11.0	50.4	22.8	22.5	41.4	35.1	46.5	47.8	41.3	56.6	25.8	44.1	40.3	49.5	55.2	36.2	50.5	59.5	41.2	42.2	30.3	53.1	40.2	66.5	36.0	46.7	44.8	32.6	26.7	49.3	39.4	25.3	15.8	15.7	19.0	22.0	24.5	19.6	24.5
Energy (GWh)			897.6	809.6	597.9	718.2	935.1	946.6	974.8	912.3	812.7	772.3	766.4	796.4	1060.9	1042.7	1058.4	1089.2	1001.6	982.7	1078.5	903.1	986.8	1067.3	1092.4	995.9	1078.6	1013.9	1040.5	825.9	1142.0	1104.9	2595.6	2075.4	1797.8	2343.0	2353.2	2193.2	2146.5	2982.4

SMEC

ANNEXURE -7.5 COMPUTATION FOR 90% & 50% DEPENDABLE YEARS BASED ON ANNUAL ENERGY (JUNE1977-MAY 2015) AT SIRKARI BHYOL BARRAGE SITE

A- ANNUAL ENERGY

No.	Year	ENERGY(GWh)
1	1977 - 1978	897.60
2	1978 - 1979	808.62
3	1979 - 1980	597.86
4	1980 - 1981	718.25
5	1981 - 1982	935.05
6	1982 - 1983	946.61
7	1983 - 1984	974.79
8	1984 - 1985	912.34
9	1985 - 1986	**912.65**
10	1986 - 1987	772.31
11	**1987 - 1988**	766.40
12	1988 - 1989	786.38
13	1989 - 1990	1060.45
14	1990 - 1991	1042.73
15	1991 - 1992	1058.37
16	1992 - 1993	1089.19
17	1993 - 1994	1001.64
18	1994 - 1995	982.72
19	1995 - 1996	1078.48
20	1996 - 1997	903.07
21	1997 - 1998	986.84
22	1998 - 1999	1057.33
23	1999 - 2000	1082.36
24	2000 - 2001	995.86
25	2001 - 2002	1078.60
26	**2002 - 2003**	1013.87
27	2003 - 2004	1040.54
28	2004 - 2005	925.87
29	2005 - 2006	1143.03
30	2006 - 2007	1104.94
31	2007 - 2008	2595.63
32	2008 - 2009	2075.44
33	2009 - 2010	1787.79
34	2010 - 2011	2343.00
35	2011 - 2012	2353.25
36	2012 - 2013	2193.18
37	2013 - 2014	3146.54
38	2014 - 2015	3382.38
	Average	1277.68

B- ENERGY IN DESCENDING ORDER

Year	ENERGY(GWh)	Ranking
2014 - 2015	3382.38	1
2013 - 2014	3146.54	2
2007 - 2008	2595.63	3
2011 - 2012	2353.25	4
2010 - 2011	2343.00	5
2012 - 2013	2193.18	6
2008 - 2009	2075.44	7
2009 - 2010	1787.79	8
2005 - 2006	1143.03	9
2006 - 2007	1104.94	10
1992 - 1993	1089.19	11
1999 - 2000	1082.36	12
2001 - 2002	1078.60	13
1995 - 1996	1078.48	14
1989 - 1990	1060.45	15
1991 - 1992	1058.37	16
1998 - 1999	1057.33	17
1990 - 1991	1042.73	18
2003 - 2004	1040.54	19
2002 - 2003	**1013.87**	**20**
1993 - 1994	1001.64	21
2000 - 2001	995.86	22
1997 - 1998	986.84	23
1994 - 1995	982.72	24
1983 - 1984	974.79	25
1982 - 1983	946.61	26
1981 - 1982	935.05	27
2004 - 2005	925.87	28
1985 - 1986	912.65	29
1984 - 1985	912.34	30
1996 - 1997	903.07	31
1977 - 1978	897.60	32
1978 - 1979	808.62	33
1988 - 1989	786.38	34
1986 - 1987	772.31	35
1987 - 1988	**766.40**	**36**
1980 - 1981	718.25	37
1979 - 1980	597.86	38

C= DEPENDABLE YEARS

No. of years of data (N) = 38

Description		Rank			ENERGY(GWh)	Corresponding Year
90% Dependable Year	((N+1)×0.9)	39×0.9 =	35.1	36	766.40	1987 - 1988
50% Dependable Year	((N+1)×0.5)	39×0.5 =	19.5	20	1013.87	2002 - 2003

SMEC

ANNEXURE - 7.6 POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY WITH 90% DEPENDABLE YEAR (1987-88) FOR DISCHARGE DATA JUNE 1977 TO MAY 2015 AT SIRKARI BHYOL BARRAGE SITE

FRL of Reservoir	2080.0	Turbine Efficiency	93.5%
MDDL	2079.0	Generator Efficiency	98.5%
Tail Water Level	1721.5	Combined ffciency	92.10%
Gross Head (monsoon period)	358.50		
Gross Head (non-monsoon period)	358.50		

Month	Days		Inflow (Gl) Cumecs	Gross Head (m)	Head Loss (m)	Net Head (m)	Power Potential (MW)	Unrestricted Energy (GWh)	Installed Cap 104 MW		Installed Cap 106 MW		Installed Cap 108 MW		Installed Cap 110 MW		Installed Cap 112 MW		Installed Cap 114 MW		Installed Cap 116 MW		Installed Cap 118 MW		Installed Cap 120 MW		Installed Cap 122 MW		Installed Cap 124 MW		Installed Cap 126 MW		Installed Cap 128 MW		Installed Cap 130 MW		Installed Cap 132 MW		Installed Cap 134 MW	
									Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)
June	10	I	36.37	357.83	6.37	351.46	115.50	27.72	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.72	115.50	27.72	115.50	27.72	115.50	27.72	115.50	27.72	115.50	27.72	115.50	27.72	115.50	27.72	115.50	27.72
	10	II	37.37	357.83	6.37	351.46	116.68	28.48	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	116.00	28.32	116.68	28.48	116.68	28.48	116.68	28.48	116.68	28.48	116.68	28.48	116.68	28.48	116.68	28.48
	10	III	37.77	357.83	6.37	351.46	119.95	28.79	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	116.00	28.32	119.95	28.79	119.95	28.79	119.95	28.79	119.95	28.79	119.95	28.79	119.95	28.79	119.95	28.79
July	10	I	27.57	357.83	6.37	351.46	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01	87.56	21.01
	10	II	29.07	357.83	6.37	351.46	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16	92.32	22.16
	11	III	44.67	357.83	6.37	351.46	141.86	37.45	104.00	27.46	106.00	27.98	108.00	28.51	110.00	29.04	112.00	29.57	114.00	30.10	116.00	30.62	118.00	31.15	120.00	31.68	122.00	32.21	124.00	32.74	126.00	33.26	128.00	33.79	130.00	34.32	132.00	34.85	134.00	35.38
August	10	I	34.67	357.83	6.37	351.46	110.10	26.42	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42	110.10	26.42
	10	II	35.77	357.83	6.37	351.46	113.59	27.26	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	113.59	27.26	113.59	27.26	113.59	27.26	113.59	27.26	113.59	27.26	113.59	27.26	113.59	27.26	113.59	27.26	113.59	27.26	113.59	27.26
	11	III	42.67	357.83	6.37	351.46	135.51	35.77	104.00	27.46	106.00	27.98	108.00	28.51	110.00	29.04	112.00	29.57	114.00	30.10	116.00	30.62	118.00	31.15	120.00	31.68	122.00	32.21	124.00	32.74	126.00	33.26	128.00	33.79	130.00	34.32	132.00	34.85	134.00	35.38
Sept	10	I	32.47	357.83	6.37	351.46	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52	102.16	24.52
	10	II	32.87	357.83	6.37	351.46	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43	72.63	17.43
	10	III	14.57	357.83	6.37	351.46	46.27	11.11	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10	46.27	11.10
Oct	10	I	12.26	357.83	6.37	351.46	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36	39.01	9.36
	10	II	9.18	357.83	6.37	351.46	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00	29.16	7.00
	11	III	8.28	357.83	6.37	351.46	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94	26.30	6.94
Nov	10	I	9.23	357.83	6.37	351.46	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03	29.30	7.03
	10	II	7.73	357.83	6.37	351.46	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89
	10	III	7.73	357.83	6.37	351.46	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89	24.54	5.89
Dec	10	I	6.83	357.83	6.37	351.46	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20
	10	II	6.33	357.83	6.37	351.46	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82	20.09	4.82
	11	III	6.93	357.83	6.37	351.46	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81	22.00	5.81
Jan	10	I	8.53	357.83	6.37	351.46	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19	25.81	6.19
	10	II	7.43	357.83	6.37	351.46	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66	23.58	5.66
	11	III	7.43	357.83	6.37	351.46	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23	23.58	6.23
Feb	10	I	7.63	357.83	6.37	351.46	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81	24.22	5.81
	10	II	7.83	357.83	6.37	351.46	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96	24.85	5.96
	8	III	6.73	357.83	6.37	351.46	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10	21.36	4.10
Mar	10	I	4.18	357.83	6.37	351.46	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19	13.28	3.19
	10	II	10.56	357.83	6.37	351.46	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07	33.61	8.07
	11	III	11.02	357.83	6.37	351.46	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29	35.19	9.29
Apr	10	I	14.58	357.83	6.37	351.46	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11	46.31	11.11
	10	II	21.08	357.83	6.37	351.46	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07	66.95	16.07
	10	III	24.28	357.83	6.37	351.46	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51	77.11	18.51
May	10	I	30.89	357.83	6.37	351.46	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54	98.07	23.54
	10	II	38.38	357.83	6.37	351.46	121.89	29.25	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	121.89	29.25	121.89	29.25	121.89	29.25	121.89	29.25	121.89	29.25	121.89	29.25
	11	III	48.16	357.83	6.37	351.46	146.85	38.72	104.00	27.46	106.00	27.98	108.00	28.51	110.00	29.04	112.00	29.57	114.00	30.10	116.00	30.62	118.00	31.15	120.00	31.68	122.00	32.21	124.00	32.74	126.00	33.26	128.00	33.79	130.00	34.32	132.00	34.85	134.00	35.38

Total Annual Energy (Gwh)								557.77		510.03		514.49		519.96		523.42		527.43		531.31		534.70		537.72		540.42		542.45		544.04		545.62		547.21		548.79		550.37		551.96
Monsoon Energy (Gwh) June-Sept								308.13		275.94		279.39		282.85		286.31		289.31		292.18		294.56		296.58		298.26		299.32		300.37		301.43		302.49		303.54		304.60		305.65
Total Lean period Energy (Gwh) (Nov-Feb)								68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60		68.60
Total Annual Energy with 95% machine availability								542.36		496.23		500.52		504.81		509.10		512.96		516.76		519.97		522.89		525.50		527.49		529.02		530.55		532.08		533.61		535.14		536.69
Incremental Energy (GWh)										4.46		4.46		4.46		4.46		4.01		3.89		3.38		3.03		2.70		2.04		1.58		1.58		1.58		1.58		1.58		1.58
% Potential Utilised								100%		91.49%		92.29%		93.09%		93.87%		94.58%		95.27%		95.87%		96.41%		96.89%		97.26%		97.54%		97.82%		98.11%		98.39%		98.67%		98.95%
Plant Load Factor (%) - Annual										55.68 %		55.41 %		54.85 %		54.32 %		53.76 %		53.20 %		52.62 %		52.02 %		51.41 %		50.76 %		50.08 %		49.43 %		48.80 %		48.19 %		47.60 %		47.02 %
Monsoon Load Factor (%)										90.02 %		90.02 %		89.45 %		88.89 %		88.22 %		87.53 %		86.72 %		85.84 %		84.89 %		83.79 %		82.75 %		81.70 %		80.71 %		79.75 %		78.81 %		77.90 %
Plant Load Factor (%) - Lean										22.71 %		22.29 %		21.87 %		21.48 %		21.09 %		20.72 %		20.36 %		20.02 %		19.69 %		19.36 %		19.05 %		18.75 %		18.46 %		18.17 %		17.90 %		17.63 %

SMEC

ANNEXURE - 7.7 POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY WITH 50% DEPENDABLE YEAR (2002-03) FOR DISCHARGE DATA JUNE 1977 TO MAY 2015 AT SIRKARI BHYOL BARRAGE SITE

FRL of Reservoir
MDDL
Tail Water Level
Gross Head (monsoon period)
Gross Head (non-monsoon period)

Turbine Efficiency
Generator Efficiency
Combined efficiency

Month	Days		Inflow (Qt) Cumecs	Gross Head (m)	Head Loss (m)	Net Head (m)	Power Potential (MW)	Unrestricted Energy (GWh)	Installed Cap. 104 MW		Installed Cap. 106 MW		Installed Cap. 108 MW		Installed Cap. 110 MW		Installed Cap. 112 MW		Installed Cap. 114 MW		Installed Cap. 116 MW		Installed Cap. 118 MW		Installed Cap. 120 MW		Installed Cap. 122 MW		Installed Cap. 124 MW		Installed Cap. 126 MW		Installed Cap. 128 MW		Installed Cap. 130 MW		Installed Cap. 132 MW		Installed Cap. 134 MW	
									Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)
June	10	I	37.87	357.83	6.37	351.46	120.26	28.86	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	120.26	28.86	120.26	28.86	120.26	28.86	120.26	28.86	120.26	28.86	120.26	28.86
	10	II	43.57	357.83	6.37	351.46	138.36	33.21	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
	10	III	53.07	357.83	6.37	351.46	168.53	40.45	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
July	10	I	55.67	357.83	6.37	351.46	176.79	42.43	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
	10	II	49.17	357.83	6.37	351.46	156.15	37.48	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
	11	III	55.47	357.83	6.37	351.46	176.15	46.50	104.00	27.46	106.00	27.98	108.00	28.51	110.00	29.04	112.00	29.57	114.00	30.10	116.00	30.62	118.00	31.15	120.00	31.68	122.00	32.21	124.00	32.74	126.00	33.26	128.00	33.79	130.00	34.32	132.00	34.85	134.00	35.38
August	10	I	56.97	357.83	6.37	351.46	180.91	43.42	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
	10	II	54.57	357.83	6.37	351.46	173.29	41.59	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
	11	III	59.07	357.83	6.37	351.46	187.58	49.52	104.00	27.46	106.00	27.98	108.00	28.51	110.00	29.04	112.00	29.57	114.00	30.10	116.00	30.62	118.00	31.15	120.00	31.68	122.00	32.21	124.00	32.74	126.00	33.26	128.00	33.79	130.00	34.32	132.00	34.85	134.00	35.38
Sept	10	I	65.17	357.83	6.37	351.46	206.95	49.67	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
	10	II	59.97	357.83	6.37	351.46	190.44	45.71	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	118.00	28.32	120.00	28.80	122.00	29.28	124.00	29.76	126.00	30.24	128.00	30.72	130.00	31.20	132.00	31.68	134.00	32.16
	10	III	30.37	357.83	6.37	351.46	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15	96.45	23.15
Oct	10	I	29.58	357.83	6.37	351.46	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55	93.94	22.55
	10	II	23.98	357.83	6.37	351.46	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29	76.16	19.29
	11	III	21.98	357.83	6.37	351.46	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43	69.81	18.43
Nov	10	I	16.33	357.83	6.37	351.46	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44	51.84	12.44
	10	II	13.33	357.83	6.37	351.46	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16	42.32	10.16
	10	III	11.03	357.83	6.37	351.46	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40	35.01	8.40
Dec	10	I	10.33	357.83	6.37	351.46	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87
	10	II	9.43	357.83	6.37	351.46	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18	29.93	7.18
	11	III	9.73	357.83	6.37	351.46	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15	30.89	8.15
Jan	10	I	10.63	357.83	6.37	351.46	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10	33.74	8.10
	10	II	10.33	357.83	6.37	351.46	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87	32.79	7.87
	11	III	11.33	357.83	6.37	351.46	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50	35.97	9.50
Feb	10	I	9.73	357.83	6.37	351.46	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41
	10	II	9.73	357.83	6.37	351.46	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41	30.89	7.41
	8	III	8.13	357.83	6.37	351.46	25.81	4.95	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96	25.81	4.96
Mar	10	I	7.78	357.83	6.37	351.46	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93	24.72	5.93
	10	II	7.18	357.83	6.37	351.46	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47	22.81	5.47
	11	III	11.58	357.83	6.37	351.46	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71	36.78	9.71
Apr	10	I	16.08	357.83	6.37	351.46	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26	51.07	12.26
	10	II	24.58	357.83	6.37	351.46	78.06	18.74	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73	78.06	18.73
	10	III	29.68	357.83	6.37	351.46	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62	94.26	22.62
May	10	I	29.38	357.83	6.37	351.46	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39	93.31	22.39
	10	II	36.78	357.83	6.37	351.46	116.80	28.03	104.00	24.96	106.00	25.44	108.00	25.92	110.00	26.40	112.00	26.88	114.00	27.36	116.00	27.84	116.80	28.03	116.80	28.03	116.80	28.03	116.80	28.03	116.80	28.03	116.80	28.03	116.80	28.03	116.80	28.03	116.80	28.03
	11	III	46.98	357.83	6.37	351.46	149.19	39.39	104.00	27.46	106.00	27.98	108.00	28.51	110.00	29.04	112.00	29.57	114.00	30.10	116.00	30.62	118.00	31.15	120.00	31.68	122.00	32.21	124.00	32.74	126.00	33.26	128.00	33.79	130.00	34.32	132.00	34.85	134.00	35.38
Total Annual Energy (Gwh)								605.23		610.95		617.33		623.72		630.10		636.49		642.87		649.25		655.35		661.25		666.74		672.16		677.59		683.01		688.44		693.86		699.28
Monsoon Energy (Gwh) June-Sept								481.98		302.70		308.08		313.45		318.83		324.20		329.58		334.96		340.33		345.71		350.67		355.56		360.46		365.35		370.25		375.15		380.04
Total Lean period Energy (Gwh) (Nov-Feb)								99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45		99.45
Total Annual Energy with 95% machine availability								761.13		595.81		601.93		608.04		614.16		620.28		626.39		632.51		638.33		643.97		648.21		654.39		659.57		664.74		669.92		675.10		680.28
Incremental Energy (GWh)										6.38		6.38		6.38		6.38		6.38		6.38		6.38		6.10		5.90		5.49		5.42		5.42		5.42		5.42		5.42		5.42
% Potential Utilised								100%		76.28%		77.06%		77.84%		78.62%		79.41%		80.19%		80.97%		81.72%		82.44%		83.11%		83.77%		84.44%		85.1%		85.76%		86.43%		87.09%
Plant Load Factor (%) - Annual										67.06 %		66.48 %		65.93 %		65.39 %		64.87 %		64.37 %		63.89 %		63.40 %		62.90 %		62.39 %		61.88 %		61.39 %		60.91 %		60.45 %		60.01 %		59.57 %
Monsoon Load Factor (%)										99.40 %		99.26 %		99.12 %		98.99 %		98.86 %		98.74 %		98.62 %		98.50 %		98.39 %		98.17 %		97.93 %		97.70 %		97.48 %		97.27 %		97.06 %		96.86 %
Plant Load Factor (%) - Lean										32.93 %		32.31 %		31.71 %		31.13 %		30.56 %		30.04 %		29.52 %		29.02 %		28.54 %		28.07 %		27.62 %		27.18 %		26.76 %		26.34 %		25.95 %		25.56 %

SMEC
Member of the Surbana Jurong Group

Annexure 7.8 - Computation of Peaking Hours in 90% Dependable Year

Month	Days	Inflow (m^3/s) in 90% Dep. Year	Design Discharge (m^3/s)	Peaking Time Based on Live Storage (Hour)	Peaking Time in a day(Hour)
June	10	36.37	37.8	8.02	23.10
	10	37.37	37.8	24.00	23.74
	10	37.77	37.8	24.00	23.99
July	10	27.57	37.8	1.11	17.51
	10	29.07	37.8	1.30	18.46
	11	44.67	37.8	24.00	24.00
Aug	10	34.67	37.8	3.64	22.02
	10	35.77	37.8	5.63	22.72
	11	42.67	37.8	24.00	24.00
Sept	10	32.17	37.8	2.02	20.43
	10	22.87	37.8	0.76	14.53
	10	14.57	37.8	0.49	9.25
Oct	10	12.28	37.8	0.45	7.80
	10	9.18	37.8	0.40	5.83
	11	8.28	37.8	0.39	5.26
Nov	10	9.23	37.8	0.40	5.86
	10	7.73	37.8	0.38	4.91
	10	7.73	37.8	0.38	4.91
Dec	10	6.83	37.8	0.37	4.34
	10	6.33	37.8	0.36	4.02
	11	6.93	37.8	0.37	4.40
Jan	10	8.13	37.8	0.38	5.16
	10	7.43	37.8	0.37	4.72
	11	7.43	37.8	0.37	4.72
Feb	10	7.63	37.8	0.38	4.84
	10	7.83	37.8	0.38	4.97
	8	6.73	37.8	0.37	4.27
Mar	10	4.18	37.8	0.34	2.66
	10	10.58	37.8	0.42	6.72
	11	11.08	37.8	0.43	7.04
Apr	10	14.58	37.8	0.49	9.26
	10	21.08	37.8	0.68	13.39
	10	24.28	37.8	0.84	15.42
May	10	30.88	37.8	1.65	19.61
	10	38.38	37.8	24.00	24.00
	11	46.18	37.8	24.00	24.00
			TOTAL=	177.55	441.86

Months	Minimum Inflow (m3/s)	Design Discharge	Min Peaking Time (Hrs.)	Min Peaking Time (Hrs.)
Dec to March (Non-monsoon)	4.18	37.79	0.34	2.66

Minimum peaking time =	0.34	hrs
Storage available =	40900	cum
Storage time =	2.72	hrs
Total time =	3.05	hrs
Total peaking in a day	2.66	hrs

Annexure 7.9 -Sirkar Bhyol Rupsiabagar HEP

INCREMENTAL ENERGY BENEFITS IN A 90% DEPENDABLE YEAR

Installed Capacity	Annual Energy, MU	Annual Load Factor (%)	kWh/kW	d kWh/d kW	Incremental Energy, MU
104	510.03	55.98	4904.1		
106	514.49	55.41	4853.7	2232.0	4.46
108	518.96	54.85	4805.1	2232.0	4.46
110	523.42	54.32	4758.4	2232.0	4.46
112	527.43	53.76	4709.2	2004.0	4.01
114	531.31	53.20	4660.6	1942.8	3.89
116	534.70	52.62	4609.5	1692.0	3.38
118	537.72	52.02	4557.0	1512.0	3.02
120	540.42	51.41	4503.5	1347.6	2.70
122	542.45	50.76	4446.3	1018.8	2.04
124	544.04	50.08	4387.4	792.0	1.58
126	545.62	49.43	4330.3	792.0	1.58
128	547.21	48.80	4275.0	792.0	1.58
130	548.79	48.19	4221.5	792.0	1.58
132	550.37	47.60	4169.5	792.0	1.58
134	551.96	47.02	4119.1	792.0	1.58

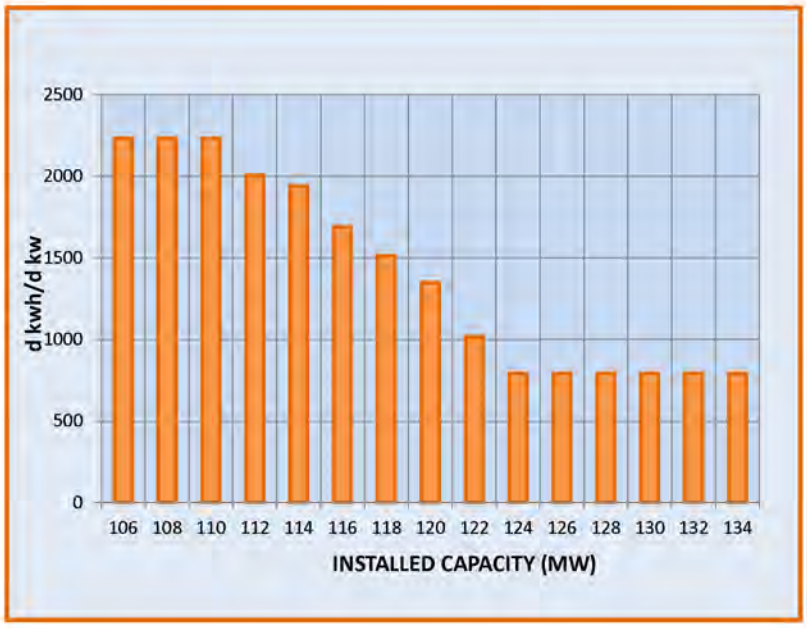


FIG 7.1
INCREMENTAL ENERGY VS INSTALLED CAPACITY
DATA (JUNE1977-MAY 2015), 90% DEP. YEAR 1987-88 , 50% DEP. YEAR 2002-03

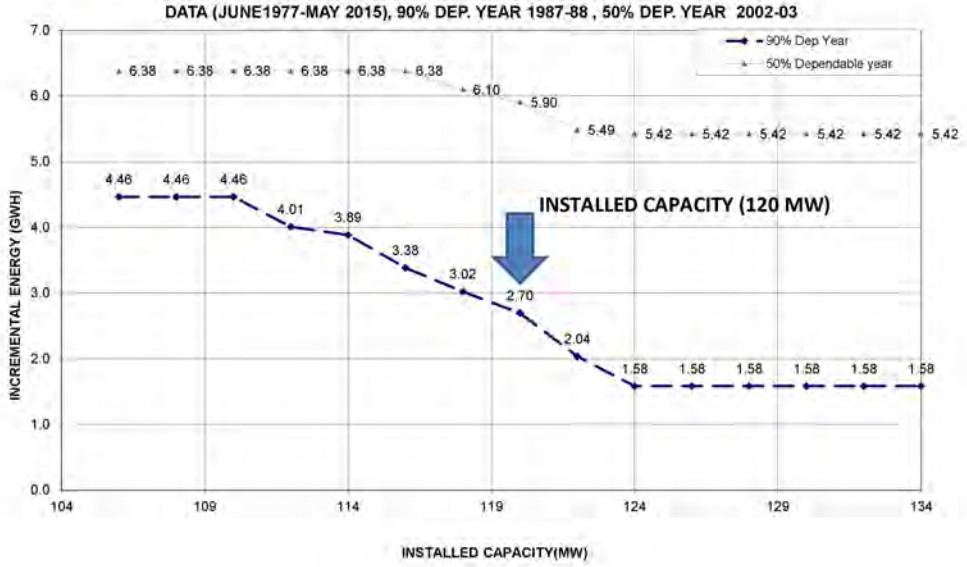


FIGURE -7.2 - POTENTIAL UTILISED VS INSTALLED CAPACITY
DATA : (JUNE1977-MAY 2015), 90% DEP. YEAR 1987-88 , 50% DEP. YEAR 2002-03

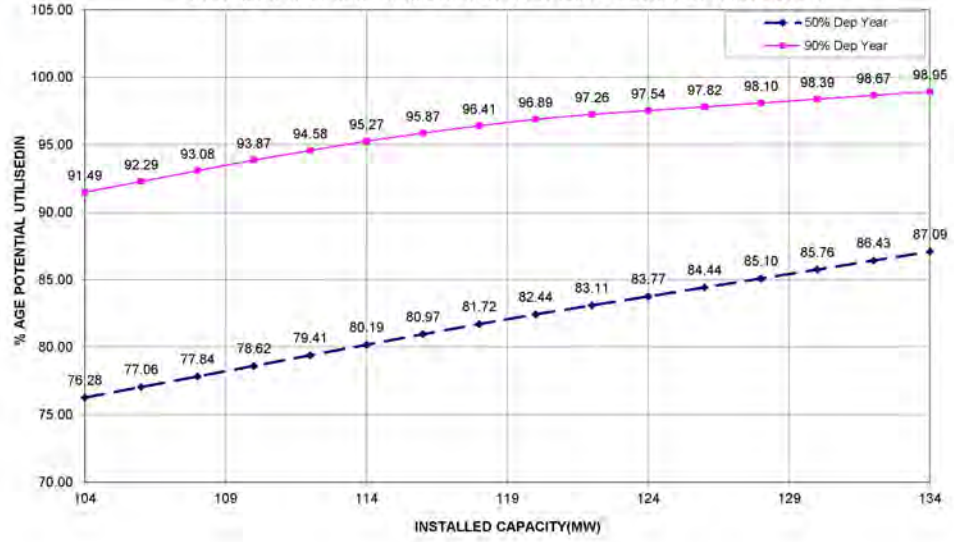


FIGURE -7.3 - PLANT LOAD FACTOR VS INSTALLED CAPACITY
DATA : (JUNE1977-MAY 2015), 90% DEP. YEAR 1987-88 , 50% DEP. YEAR 2002-03

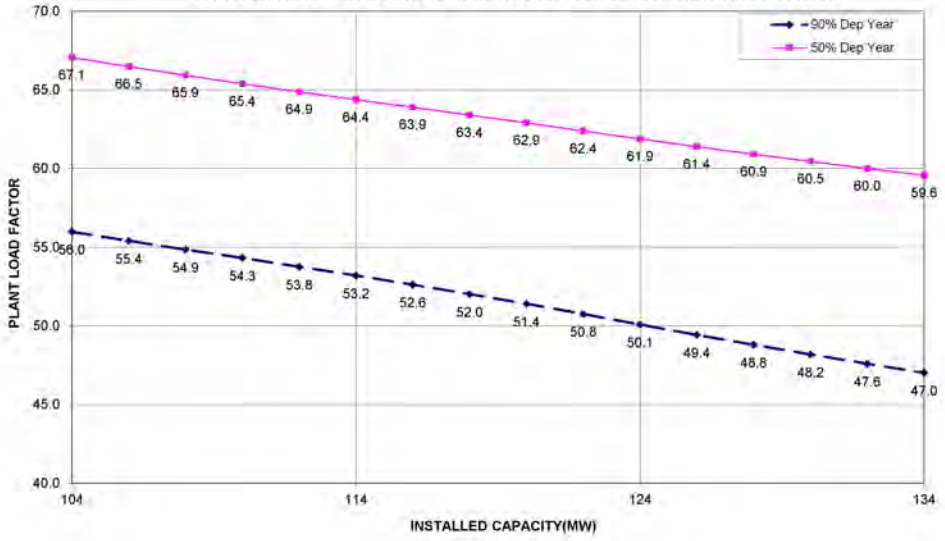
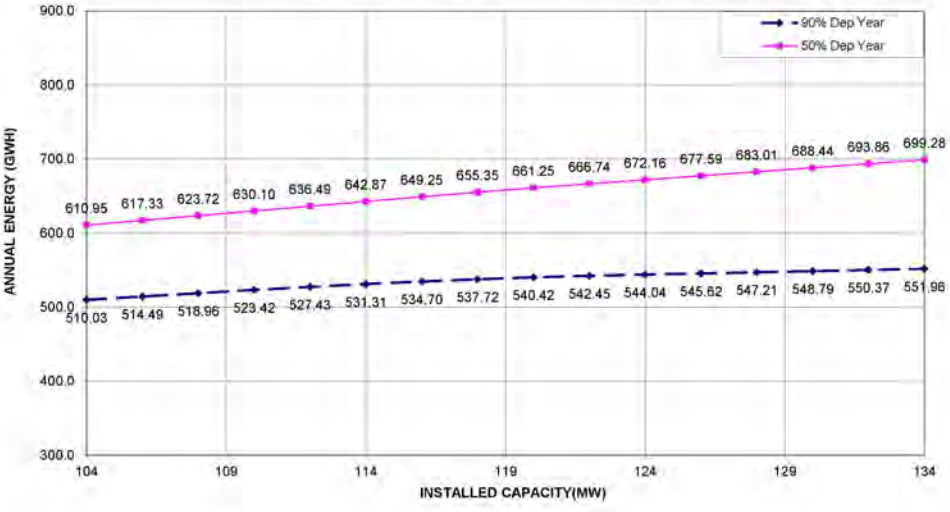


FIGURE -7.4 - ANNUAL ENERGY VS INSTALLED CAPACITY
DATA : (JUNE1977-MAY 2015), 90% DEP. YEAR 1987-88 , 50% DEP. YEAR 2002-03



ATTACHMENTS

ATTACHMENT A

EXPERT APPRAISAL COMMITTEE,
MOEF APPROVAL OF TOR

No.J-12011/12/2015-IA-I
Ministry of Environment, Forest & Climate Change
Government of India
(IA-I Division)

Indira Paryavan Bhavan
3rd Floor, Vayu Wing
Jor Bagh Road
New Delhi – 110 003

Date: 20th January, 2016

To

Shri. S.C. Baluni
General Manager (C-NP)
M/s Uttarakhand Jal Vidyut Nigam Ltd.
Ujjwal, Maharani Bagh,
GMS Road, Dehradun-248006

Subject: Sirkari-Bhyol Rupsiabagar HEP (168 MW) in Pithoragarh District of Uttarakhand by M/s. UJVN Ltd– for Scoping / TOR - regarding.

Sir,

This is with reference to your letter No. 1854/UJVN Ltd. /03/Dir (P)/GM(C-NP)/SBR-MoEF dated 14.10.2015 on the above mentioned subject.

2. The said proposal was appraised by the Environment Appraisal Committee (EAC) for River Valley and Hydroelectric Power Projects (RV&HEP) in its meetings held on 26-27th October, 2015. The comments and observations of EAC may be seen in the Minutes of the meeting are available on the Ministry's web-site.

3. It is noted that the proposed development is on Goriganga River (a tributary of Kali River) 470 m downstream of confluence of Jaulchidda Gad with Goriganga in Pithoragarh District of Uttarakhand. The project envisages construction of a 12 m high barrage across Goriganga River to generate 168 MW of hydropower. This is run-of-the-river scheme. The catchment area of the project is 957 Sq.km. The total land requirement for the project is about 30 ha. Total submergence area is 0.03 ha. An underground powerhouse is proposed with 4 units of 42 MW capacity each. The total cost of the project is about Rs.1233.79 Crores and proposed to be completed in 54 months.

4. Based on recommendations of the EAC, the Ministry of Environment & Forests hereby accords a fresh clearance for pre-construction activities at the proposed site as per the provisions of the Environmental Impact Assessment Notification, 2006 and subsequent amendment, 2009 along with the following Terms of Reference (TOR) for preparation of EIA/EMP report. The EIA/EMP report should contain the information in accordance with provisions & stipulations as given in the **Annexure-I**. While preparing

the EIA/EMP report prevailing norms should be followed with respect to environmental flows and muck disposal sites

5. The Consultant engaged for preparation of EIA/EMP report has to be registered with Quality Council of India (QCI)/NABET under the scheme of Accreditation & Registration of MoEF. This is a pre-requisite.

6. Consultants shall include a "Certificate" in EIA/EMP report regarding portion of EIA/EMP prepared by them and data provided by other organization(s)/ laboratories including status of approval of such laboratories.

7. The draft EIA/EMP report prepared as per the above Terms of References should be submitted to the State Pollution Control Board/Committee concerned for conducting Public Hearing / Consultation as per the provisions stipulated in EIA Notification of 2006. The draft EIA/EMP report is to be submitted to SPCB etc sufficiently before the expiry of the ToR validity so that necessary amendments in EIA/EMP can be undertaken based on public hearing and the same is submitted to MoEF &CC before expiry of validity.

8. All issues discussed in the Public Hearing/Consultations should be addressed and incorporated in the EIA/EMP Report. Final EIA/EMP report should be submitted to the Ministry for Environmental Clearance only after incorporating these issues before the expiry of validity of ToR.

9. The TOR will remain valid for a period of 4 years from the date of issue of this letter for submission of EIA/EMP report along with public consultation. The ToR will stand lapsed on completion of 4 years time in case final EIA/EMP is not submitted and the validity is not renewed.

10. In case of any change in the Scope of the Project such as capacity enhancement, shifting of dam site/powerhouse and change in submergence etc., fresh scoping clearance has to be obtained by the project proponent.

11. Information pertaining to Corporate Environmental Responsibility and Environmental Policy shall be provided in the EIA/EMP Report as per this Ministry's OM No.J-11013/25/2014-IA-I dated 11.8.2014.

12. The EIA/EMP Report must contain an Index showing details of compliance of all ToR conditions. The Index will comprise of page no. etc., vide which compliance of a specific ToR is available. It may be noted that without this index, EIA/EMP report will not be accepted.

13. The scoping/TOR clearance is being considered by MoEF & CC subject to the outcome of the court order and the project proponent shall bound by the decision of the MoEF & CC arising out of such outcome of court order.

14. Recommended of additional measures contained in EB report dated 19.10.2015 on 6 HEBs of Uttarakhand may also be examined and necessary safeguard measures included in the EMP.

15. In case the validity is to be extended, necessary application is to be submitted at least 3 months before expiry of validity of TOR.

16. This has approval of the Competent Authority.

Yours faithfully,

(B.B. Barman)
Director

Copy to:

1. The Secretary, Ministry of Power, Shram Shakti Bhawan, Rafi Marg, New Delhi -1
2. The Secretary, Ministry of Water Resources, RD & GR, Shram Shakti Bhawan, Rafi Marg, New Delhi -.
3. The Addl. Chief Secretary, Department of Forest & Environment, Government of Uttarakhand., Uttarakhand Secretariat, 4, Subhash Road, Dehradun – 24800. UK.
4. The Principal Secretary, Department of Energy, Government of Uttarakhand, Uttarakhand Secretariat, 4, Subhash Road, Dehradun – 24800. UK
5. The Chief Engineer, Project Appraisal Directorate, Central Electricity Authority, Sewa Bhawan, R. K. Puram, New Delh-110066.
6. The Addl. PCCF (C), Regional Office, Ministry of Environment, Forests & Climate Change, GOI, FRI Campus, Pearson Road, P.O. New Forest, Dehradun – 248006. UK.
7. Member Secretary, Uttarakhand Environment Protection & Pollution Control Board, Government of Uttarakhand, 29/20, Nemi Road, Dehradun-248001. UK.
8. EI-Division, Ministry of Environment & Forests, New Delhi-110003.
9. PS to JS (BS)/B.B.Barman (Director)/PV Subba Rao(Sci-C)
10. NIC Cell – for uploading in MOEF's website.
11. Guard File.

(B.B. Barman)
Director

No. J- 12011/12/2015-IA. I (R) Pt.
Ministry of Environment, Forest & Climate Change
Government of India
(I.A I Division)

Indira Paryavaran Bhavan
3rd Floor, Vayu Wing
Jor Bagh Road
New Delhi-110003

Dated: 17th April, 2020

To

The General Manager (C-NP)
M/s Uttarakhand Jal Vidyut Nigam Ltd.
Ujjwal, Maharani Bagh,
GMS Road, Dehradun-248006

Sub: Sirkari-Bhyol Rupsiabagar HEP (168 MW) in Pithoragarh District of Uttarakhand by M/s. UJVN Ltd: regarding extension of validity of Terms of Reference (ToR).

Sir,

This is in reference to your Online proposal number IA/UK/RIV/130432/2019 and letter dated 20.12.2019 on the above mentioned subject.

2. Terms of Reference to the Sirkari-Bhyol Rupsiabagar HEP (168 MW) was issued vide letter dated 20.01.2016 with validity of four years i.e upto 19.01.2020. Request regarding extension of validity of ToR beyond four years was considered in the Ministry. Based on the information furnished regarding extension of validity period, Ministry hereby extends the validity of Terms of Reference for another one year i.e upto 19.01.2021.

3. It is advised to conduct the Public Consultation and submit the EIA/EMP report to the Ministry as per the ToR issued vide letter dated 20.01.2016, within the validity period i.e on or before 19.01.2021. Any proposal regarding extension of validity of ToR beyond 19.01.2021 shall not be entertained as the outer limit for validity of ToR for RIV & HEPs is five years.

4. Baseline data and Public Consultation should not be older than three years at the time of submission of the proposal for grant of Environmental Clearance to the Ministry. Further, details of Corporate Environmental Responsibility (CER) shall be incorporated in the EIA/EMP report as per the Ministry's Office Memorandum dated 01st May 2018.

This has approval of the Competent Authority.

Yours faithfully

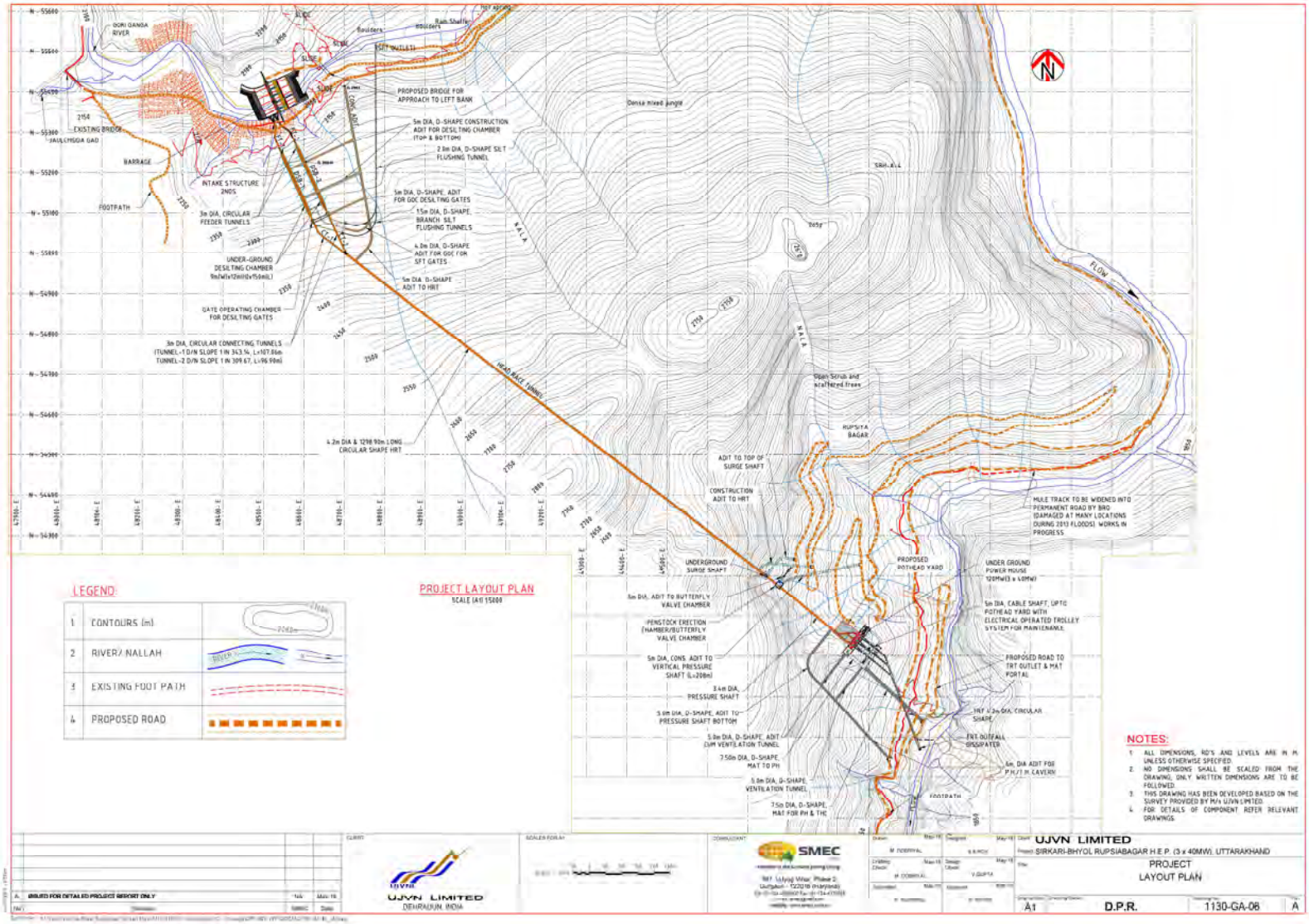
(Dr. S. Kerketta)
Director
Telefax:011-24695314

Copy to:

1. The Secretary, Ministry of Power, Shram Shakti Bhawan, Rafi Marg, New Delhi -1.
2. The Secretary, Ministry of Water Resources, RD&GR, Shram Shakti Bhawan, Rafi Marg, New Delhi – 110001.
3. The Principal Secretary (Irrigation & Power), Government of Uttarakhand, Dehradun -248 006.
4. The Chief Engineer, Project Appraisal Directorate, Central Electricity Authority, Sewa Bhawan, R. K. Puram, New Delhi - 110 066.
5. The Dy. Director General of Forests, Ministry of Environment, Forest and Climate Change, Regional Office (NCZ), Subhash Road Road, Dehradun - 248001.
6. The Member Secretary, Uttarakhand Environment Protection & Pollution Control Board, Paryavaran Bhawan, E-115, Nehru Colony, Dehradun.
7. Sr. PPS to JS(GM)
8. NIC Cell - uploading on MOEF&CC website.
9. Guard File.

(Director)

ATTACHMENT B
PROJECT LAYOUT PLAN


GORI GANGA RIVER
EXISTING BRIDGE
JAULJHIGDA GAD
BARRAGE
FOOTPATH
INTAKE STRUCTURE 2NOS
3m DIA, CIRCULAR FEEDER TUNNELS
UNDER-GROUND DESILTING CHAMBER 9m(W)x12m(H)x150m(L)
GATE OPERATING CHAMBER FOR DESILTING GATES
3m DIA, CIRCULAR CONNECTING TUNNELS (TUNNEL-1 D/N SLOPE 1 IN 363.74, L=107.86m TUNNEL-2 D/N SLOPE 1 IN 309.67, L=96.90m)
4.2m DIA & 1298.90m LONG CIRCULAR SHAPE HRT
PROPOSED BRIDGE FOR APPROACH TO LEFT BANK
5m DIA, D-SHAPE CONSTRUCTION ADIT FOR DESILTING CHAMBER (TOP & BOTTOM)
2.8m DIA, D-SHAPE SILT FLUSHING TUNNEL
5m DIA, D-SHAPE, ADIT FOR GOC DESILTING GATES
15m DIA, D-SHAPE, BRANCH SILT FLUSHING TUNNELS
4.0m DIA, D-SHAPE ADIT FOR GOC FOR SFT GATES
5m DIA, D-SHAPE ADIT TO HRT
HEAD RACE TUNNEL
Dense mixed jungle
Open Scrub and scattered trees
RUPSIYA BAGAR
ADIT TO TOP OF SURGE SHAFT
CONSTRUCTION ADIT TO HRT
MULE TRACK TO BE WIDENED INTO PERMANENT ROAD BY BRO (DAMAGED AT MANY LOCATIONS DURING 2013 FLOODS). WORKS IN PROGRESS
UNDERGROUND SURGE SHAFT
PROPOSED POTHEAD YARD
UNDER GROUND POWER HOUSE 120MW(3 x 40MW)
5m DIA, ADIT TO BUTTERFLY VALVE CHAMBER
PENSTOCK ERECTION CHAMBER/BUTTERFLY VALVE CHAMBER
5m DIA, CONS. ADIT TO VERTICAL PRESSURE SHAFT (L=208m)
3.4m DIA, PRESSURE SHAFT
5.0m DIA, D-SHAPE, ADIT TO PRESSURE SHAFT BOTTOM
5.0m DIA, D-SHAPE, ADIT CUM VENTILATION TUNNEL
7.50m DIA, D-SHAPE, MAT TO PH
5.0m DIA, D-SHAPE, VENTILATION TUNNEL
7.5m DIA, D-SHAPE, MAT FOR PH & TRT
5m DIA, CABLE SHAFT, UPTO POTHEAD YARD WITH ELECTRICAL OPERATED TROLLEY SYSTEM FOR MAINTENANCE
PROPOSED ROAD TO TRT OUTLET & MAT PORTAL
TRT U 2m DIA, CIRCULAR SHAPE
TRT OUTFALL DISSIPATER
6m DIA ADIT FOR P.H./T.H. CAVERN
FOOTPATH
FLOW
N
LEGEND
1 CONTOURS (m)
2 RIVER/ NALLAH
3 EXISTING FOOT PATH
4 PROPOSED ROAD
PROJECT LAYOUT PLAN
SCALE (A0) 1:5000
NOTES:
1. ALL DIMENSIONS, RD'S AND LEVELS ARE IN M. UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE SCALED FROM THE DRAWING, ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. THIS DRAWING HAS BEEN DEVELOPED BASED ON THE SURVEY PROVIDED BY M/s UJVN LIMITED.
4. FOR DETAILS OF COMPONENT REFER RELEVANT DRAWINGS.
A ISSUED FOR DETAILED PROJECT REPORT ONLY
UJVN LIMITED
DEHRADUN, INDIA
SMEC
UJVN LIMITED
SIRKARI-BHYOL RUPSIABAGAR H.E.P. (3 x 40MW), UTTARAKHAND
PROJECT LAYOUT PLAN
A1
D.P.R.
1130-GA-08
A

ATTACHMENT C
CEA APPROVAL

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
जल विद्युत परियोजना मूल्यांकन-I प्रभाग
Hydro Project Appraisal-I Division

विषय: Sirkari-Bhyol Rupsiyabagar H.E. Project in Uttarakhand by UJVN Ltd. – Examination of Power Potential Studies.

Reference is invited to UJVNL letter No. 576/UJVNL/03/Dir(Pro)/GM(Civ)/BSR dated 27.04.2017 submitting therewith a chapter on power potential studies of the said project for examination. Subsequently, revised PPS chapter was submitted by the developer vide letter dated 16.06.2017.

As per the said PPS Chapter, Sirkari-Bhyol Rupsiyabagar H.E. Project is proposed as a run of-river scheme with very low storage of 0.0409 Mcum on Goriganga river. Installed capacity of 134 MW was proposed based on 10-daily water availability series approved and communicated to the developer by CWC vide letter dated 10.03.2017. Operating levels (FRL & TWL) have been approved by govt. of Uttarakhand vide letter dated 03.12.2014. ToR for preparation of EIA/EMP were accorded clearance by MoEF&CC vide their letter dated 20.01.2016 along with downstream environmental flow releases.

Following parameters have been considered in the examination of power potential studies of this project:

i)	10-daily water flow series	: 1977-78 to 2014-15
ii)	Hydrological year	: June to May
iii)	90% dependable year	: 1987-88
iv)	D/s environmental flow Releases	
	- Monsoon period	: 30% of June to September average inflows
	- Lean period	: 20% of Nov. to Feb. average inflows
	- Non-monsoon non-lean period	: 25% of Oct., March, April & May average inflows
v)	FRL	: 2080.0 m
vi)	MDDL	: 2078.0 m
vi)	TWL	: 1721.5 m
vii)	Live storage	: 0.0409 MCM
viii)	Head losses	: 9.2m (yet to be Approved by CWC)
ix)	Combined turbo-generator efficiency	: 92.09 % (yet to be Approved by HE&TD)

The power potential studies submitted by the developer have been examined in this office and it is observed that the Installed Capacity of 120 MW may be adopted for framing the DPR. The design energy of the said project is envisaged to be 529.12 MU. However, head losses in water conductor system are yet to be approved by HCD Dte. of CWC & HE&TD Div. of CEA and combined turbine-generator efficiency by HE&TD Div. of CEA.

Further, the installed capacity and design energy may be reviewed on account of following:

i) Any change in operating leves (FRL, MDDL, TWL) etc.
ii) Any change in water conductor system losses.
iii) Any changes in downstream environmental flow releases.
iv) Any change in efficiency of turbine and/or generator.
v) Any other aspect, which is derived during detailed examination of the projects.

Design Energy calculations of Sirkari-Bhyol Rupsiyabagar H.E. Project is enclosed at **Annex-I.**

This issues with the approval of competent authority.

21.7.17

(श्रवण कुमार)
निदेशक (एचपीए-I)
ईमेल:dirhpa3@gmail.com

Director (PAC), CEA

No.: 207/1/2014/HPA/ 846 Dated: 21.07.2017

Copy to. General Manager (Civil-New Projects), UJVN Ltd.
Ganga Bhawan, Yamuna Colony,
Dehradun (Uttarakhand) - 248001

FRL (m)	2080	Unrestrcited Annual Energy Generation		553.73	MU
MDDL (m)	2078				
TWL (max)	1721.5	Installed Capacity		120	MW
Head Loss (m)	9.2	Design Flow		38.10	Cumec
Net Head (m)	348.6	Riparian Flows (e-flows)	Jun-Sept	14.13	Cumec
Overall Efficiency	0.9209		Nov-Feb	1.87	Cumec
Live Stogare (Mcum):	0.0409		Rest of year	6.42	Cumec
Annual Load Factor %	51.13	Lean Period Load Factor		19.83	%

Month	Days	Total Inflow (cumec)	Inflows after e-flows releases (cumec)	Flow used for Power Generation (cumec)	Total Energy Generation with 100% m/c (MU)	Total Energy Generation with 95% m/c (MU)
JUNE	10	50.50	36.37	36.37	27.49	27.36
	10	51.50	37.37	37.37	28.25	27.36
	10	51.90	37.77	37.77	28.55	27.36
JULY	10	41.70	27.57	27.57	20.84	20.84
	10	43.20	29.07	29.07	21.98	21.98
	11	58.80	44.67	38.10	31.68	30.10
AUGUST	10	48.80	34.67	34.67	26.21	26.21
	10	49.90	35.77	35.77	27.04	27.04
	11	56.80	42.67	38.10	31.68	30.10
SEPTEMBER	10	46.30	32.17	32.17	24.32	24.32
	10	37.00	22.87	22.87	17.29	17.29
	10	28.70	14.57	14.57	11.02	11.02
OCTOBER	10	18.70	12.28	12.28	9.28	9.28
	10	15.60	9.18	9.18	6.94	6.94
	11	14.70	8.28	8.28	6.89	6.89
NOVEMBER	10	11.10	9.23	9.23	6.97	6.97
	10	9.60	7.73	7.73	5.84	5.84
	10	9.60	7.73	7.73	5.84	5.84
DECEMBER	10	8.70	6.83	6.83	5.16	5.16
	10	8.20	6.33	6.33	4.78	4.78
	11	8.80	6.93	6.93	5.76	5.76
JANUARY	10	10.00	8.13	8.13	6.14	6.14
	10	9.30	7.43	7.43	5.61	5.61
	11	9.30	7.43	7.43	6.18	6.18
FEBRUARY	10	9.50	7.63	7.63	5.76	5.76
	10	9.70	7.83	7.83	5.92	5.92
	9	8.60	6.73	6.73	4.58	4.58
MARCH	10	10.60	4.18	4.18	3.16	3.16
	10	17.00	10.58	10.58	8.00	8.00
	11	17.50	11.08	11.08	9.22	9.22
APRIL	10	21.00	14.58	14.58	11.02	11.02
	10	27.50	21.08	21.08	15.94	15.94
	10	30.70	24.28	24.28	18.36	18.36
MAY	10	37.30	30.88	30.88	23.34	23.34
	10	44.80	38.38	38.10	28.80	27.36
	11	52.60	46.18	38.10	31.68	30.10
Total					**537.52**	**529.12**

ATTACHMENT D

APPROVED WATER AVAILABILITY SERIES
BY CENTRAL WATER COMMISSION

भारत सरकार
केन्द्रीय जल आयोग
जलविज्ञान (मध्य) निदेशालय

Subject: DPR of Sirkari Bhyol-Rupsiabagar (SBR) project in Pithoragarh district of Uttarakhand State

Ref: (1) Email dated: 01.03.2017 received from Charu Lohani, EE (C), SBRHEP
(2) CWC No. 01/UTT/60/2014/Hyd(N)/131-33 dated 21.02.2017

Water availability of Sirkari-Bhyol Rupsiabagar (SBR) HE Project, at DPR stage, was cleared by this office vide letter no. 1/UTT/60/2014/Hyd (N)/131-33 dated: 21.02.2017, wherein the yield series for the period of 1977-78 to 2014-15, on monthly basis, was communicated to the Project Authorities. The project authorities have subsequently requested to provide the water availability series on ten-daily basis through their email dated: 01.03.2017.

In the water availability study carried out earlier, snowmelt contribution was computed based on assumption that the snowmelt rate for a given month remains uniform throughout the month and this corresponds to the minimum flow observed in the respective month during the last 38 years, for which the discharge data is available. Accordingly, all the calculations for separating the snowmelt contribution from the total runoff were performed on monthly yield series. Now, to derive ten-daily water availability series, snowmelt contribution has been calculated on ten-daily basis, assuming a uniform rate for the entire month. This uniform rate is the same as communicated earlier to the Project Authorities. Further, all other assumptions considered in the analysis are also the same. The yield series thus generated has been attached as Annexure-I and the same may be adopted for planning and design purposes.

10/3/2017
(S. K. Sinha)
Director

General Manager (Civil-New) Projects), SJVN Ltd., "Ganga Bhawan", Yamuna Colony, Dehradoon-248001

1/UTT/60/2014/Hyd (N)/367-69 Date: 10.03.2017

Copy to: 1. Director, Project Appraisal (North) Dte., CWC, New Delhi
2. Director, P A C Dte., CEA, Sewa Bhawan, New Delhi

सातवाँ तल(दक्षिण), सेवा भवन, आर. के. पुरम सैक्टर-1, नई दिल्ली-110066
दूरभाष: 011-29583525 Email: hydcent@nic.in

Ten-daily Water availability at Sirkari-Bhyol Rupsiabagar HE Project in MCM (Monsoon Months) Annexure-I

Year	Jun			Jul			Aug			Sep			Oct			Monsoon
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	
1977-78	43.7	42.2	55.2	56.8	59.2	70.9	61.8	75.4	54.4	45.7	46.6	41.4	32.8	28.2	28.0	742.3
1978-79	58.0	58.2	69.7	58.4	55.9	66.9	70.7	58.9	66.6	57.1	45.9	37.8	30.3	26.7	25.4	786.1
1979-80	42.2	42.2	48.0	38.1	35.7	49.9	43.7	40.2	37.4	29.9	23.1	21.0	21.0	20.3	20.6	508.2
1980-81	44.3	45.1	49.6	39.0	41.5	48.4	48.6	38.7	41.9	38.6	32.4	30.2	26.8	24.5	25.0	574.7
1981-82	49.7	49.6	70.4	68.1	82.4	92.6	88.4	86.9	72.4	48.4	39.1	38.4	29.9	25.5	26.3	857.2
1982-83	52.4	67.3	63.8	60.2	67.2	86.9	82.1	89.4	90.1	58.9	48.1	31.9	26.2	23.8	23.7	871.0
1983-84	57.6	48.7	64.7	55.5	50.5	69.4	79.0	81.0	80.9	79.0	67.0	58.4	39.4	31.9	29.3	883.3
1984-85	78.8	79.1	77.5	69.5	53.4	69.4	58.1	59.2	64.4	57.7	43.8	29.0	25.3	20.8	22.1	808.4
1985-86	42.2	44.8	54.4	47.9	67.4	73.2	65.1	86.3	83.6	60.2	48.4	37.1	30.7	42.1	27.6	811.1
1986-87	46.8	66.2	83.0	66.7	78.3	83.3	66.9	58.7	48.9	38.8	24.4	17.8	13.7	13.0	11.8	718.5
1987-88	50.5	51.5	51.9	41.7	43.2	58.8	48.8	49.9	56.8	46.3	37.0	28.7	18.7	15.6	14.7	614.3
1988-89	55.4	46.1	62.9	52.3	62.1	91.2	74.0	69.3	57.2	35.2	27.7	44.5	24.9	17.9	18.4	739.0
1989-90	51.4	50.1	60.6	47.8	69.0	91.8	81.2	80.6	108.1	85.7	59.5	46.6	34.5	30.4	28.0	925.5
1990-91	64.3	61.3	53.5	47.5	63.7	57.4	49.0	86.0	59.4	71.7	57.0	45.2	33.7	26.0	22.5	798.0
1991-92	59.4	77.8	77.3	66.7	79.3	85.2	77.2	78.0	85.6	62.9	51.0	38.4	37.9	30.5	27.7	929.1
1992-93	50.4	75.5	76.0	45.7	67.6	86.0	79.3	76.9	93.3	72.5	58.9	44.8	34.1	30.7	27.9	919.4
1993-94	52.0	56.0	59.4	44.7	66.4	65.1	84.9	60.8	59.9	70.7	65.3	47.8	36.9	34.4	29.9	843.1
1994-95	67.0	66.6	93.0	64.6	61.9	81.6	68.7	69.5	90.3	64.7	46.0	37.1	30.6	27.1	27.6	896.3
1995-96	80.2	64.2	62.8	54.9	71.1	75.0	92.5	73.1	85.5	100.1	56.6	42.6	35.2	31.2	29.3	954.3
1996-97	51.2	61.2	71.5	37.9	73.2	73.2	70.8	73.8	69.3	68.8	50.9	41.1	36.1	28.0	28.0	835.0
1997-98	43.3	45.0	57.0	50.0	65.7	79.9	91.3	70.2	56.0	63.0	60.4	40.2	29.1	26.2	27.2	804.7
1998-99	56.5	51.7	79.3	70.0	72.2	88.4	97.3	94.3	82.4	56.0	44.5	47.2	38.0	41.3	36.2	955.2
1999-00	42.2	55.6	57.8	72.6	67.8	101.7	81.8	72.5	81.8	53.9	55.2	51.3	40.9	31.4	30.3	896.8
2000-01	78.0	66.7	71.6	62.5	77.8	83.5	81.8	78.1	74.3	63.1	46.6	39.7	32.8	28.1	28.3	911.8
2001-02	49.9	57.3	64.4	56.2	88.6	112.1	81.8	80.8	66.3	52.7	41.0	36.6	29.8	27.9	29.4	872.6
2002-03	52.0	57.7	67.2	69.8	63.3	69.6	71.1	68.7	73.2	79.3	74.1	44.5	36.0	30.4	28.4	835.3
2003-04	58.9	59.4	65.0	65.7	76.7	89.2	82.5	74.0	98.7	79.5	63.0	57.3	39.5	32.3	32.5	974.3
2004-05	42.2	50.9	50.6	52.4	57.0	79.5	89.1	87.8	76.9	54.0	46.3	45.1	39.8	34.9	30.0	830.4
2005-06	42.2	49.6	66.6	77.9	87.6	94.9	99.1	89.6	74.4	62.9	70.0	75.6	60.2	48.0	45.2	1043.9
2006-07	58.0	48.6	56.3	82.8	80.2	97.5	78.4	70.9	113.0	71.4	65.5	47.6	35.2	31.6	32.1	970.0
2007-08	56.2	71.8	73.1	82.0	76.7	106.7	92.3	93.9	95.7	90.9	64.4	83.1	60.4	41.9	39.8	1128.1
2008-09	47.9	79.0	72.6	65.1	68.6	100.5	76.9	73.6	78.3	51.8	47.6	53.2	37.1	31.1	30.1	913.4
2009-10	44.1	42.2	54.6	33.7	55.8	64.1	65.9	66.3	63.5	69.5	67.9	42.8	52.6	36.7	30.8	789.9
2010-11	42.2	42.2	46.3	45.1	68.6	96.5	93.8	101.7	111.7	110.9	89.4	75.3	41.7	32.0	32.5	1030.2
2011-12	42.6	56.7	78.4	85.1	71.4	112.0	87.7	100.9	103.5	75.5	70.1	42.2	33.9	29.7	29.5	1019.2
2012-13	48.4	47.1	61.3	64.1	51.9	94.7	96.0	86.2	94.6	68.4	83.9	47.9	34.0	29.1	31.9	939.5
2013-14	56.1	101.9	112.4	121.1	130.0	146.0	116.9	120.4	114.0	86.6	65.6	56.4	51.3	45.4	48.9	1372.8
2014-15	48.0	50.9	50.0	60.9	95.6	96.9	113.9	105.7	91.2	76.7	68.8	25.9	20.0	17.5	17.3	939.1

Ten-daily Water availability at Sirkari-Bhyol Rupsiabagar HE Project in MCM (Non-Monsoon Months)

Nov			Dec			Jan			Feb			Mar			Apr			May			Non-Monsoon
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	
20.0	15.5	12.7	10.8	9.4	10.0	10.7	10.4	10.7	9.1	9.0	8.2	11.8	13.9	14.2	17.1	28.6	27.5	45.9	56.8	60.1	412.1
12.8	11.3	9.9	7.6	6.5	6.2	7.3	7.0	7.3	6.8	6.8	5.5	8.5	8.5	10.0	16.7	16.7	19.7	24.4	28.9	26.8	355.4
7.3	6.4	5.7	5.4	5.0	4.9	7.1	6.6	7.3	6.8	6.8	8.5	10.8	10.6	13.9	16.7	19.5	24.1	30.2	31.4	26.8	261.9
17.2	14.0	11.4	8.8	8.0	8.1	9.7	9.1	10.6	9.6	9.5	7.6	10.8	10.3	14.2	17.2	25.0	26.6	33.7	38.8	49.4	349.5
16.5	12.0	9.4	8.5	7.8	8.2	9.4	9.0	9.5	9.2	9.2	7.1	10.7	12.2	16.5	22.3	24.0	26.8	38.2	36.1	41.9	344.2
11.9	11.0	8.2	6.8	6.1	6.3	7.9	8.7	10.0	8.8	8.5	6.6	9.6	10.9	14.6	17.2	19.5	20.6	40.9	54.1	55.5	343.9
19.2	16.8	13.5	11.8	11.1	10.9	10.6	9.6	9.6	8.4	9.0	8.8	12.2	13.1	18.1	17.0	19.3	22.0	31.5	40.5	57.0	370.1
13.9	13.0	12.7	11.9	11.4	11.2	13.3	11.9	12.8	11.4	11.7	9.8	13.6	13.8	16.8	17.9	21.3	24.1	31.9	32.9	49.3	366.2
20.4	16.0	12.3	10.4	9.4	9.5	10.7	10.1	10.7	9.8	10.1	3.0	10.8	11.1	13.1	16.7	23.7	27.2	36.8	41.6	43.6	361.9
10.1	9.0	8.9	9.1	8.3	8.4	9.6	9.6	10.1	9.1	9.4	7.7	10.1	10.9	12.9	16.7	16.7	19.8	24.4	24.4	30.8	275.7
11.1	9.6	9.6	8.7	8.2	8.8	10.0	9.3	9.3	9.5	9.7	8.6	10.6	17.0	17.5	21.0	27.5	30.7	37.3	44.8	52.6	371.5
13.6	12.1	10.4	9.1	8.4	9.3	10.0	11.3	11.0	8.9	8.7	7.2	10.6	10.9	13.6	16.8	18.9	19.5	24.4	33.9	48.1	322.5
20.5	19.1	17.7	14.9	13.9	14.6	13.5	13.0	14.1	11.0	11.5	8.9	12.6	14.2	17.0	18.4	24.0	30.4	34.6	53.1	57.8	435.1
18.3	17.2	15.2	13.8	12.1	12.8	14.7	12.6	13.6	12.1	13.5	10.5	27.6	29.3	35.6	44.9	52.9	31.0	43.2	48.7	65.8	432.6
22.1	18.8	16.4	13.9	13.5	14.8	14.9	13.5	15.2	14.1	12.1	10.3	13.5	14.8	18.8	20.3	23.5	28.6	37.0	50.9	45.6	480.4
23.3	20.9	17.4	10.8	9.0	9.3	12.4	11.9	12.1	11.7	16.7	9.3	17.9	17.5	21.5	22.6	30.6	41.6	57.0	46.7	60.2	446.0
24.8	24.0	20.6	17.4	14.8	14.3	14.5	14.8	15.4	13.5	13.1	10.5	11.8	14.2	16.5	21.7	20.2	21.6	34.7	37.8	69.8	466.3
12.3	10.8	9.3	10.7	9.2	9.3	9.5	9.7	10.0	9.1	10.1	7.4	10.1	10.0	14.7	17.3	19.8	25.0	31.1	72.0	49.2	366.3
18.8	17.6	14.8	12.4	11.6	11.8	12.4	12.7	13.9	12.2	11.8	11.7	13.0	17.0	20.8	24.1	30.5	33.6	45.4	38.1	50.3	434.2
19.2	15.8	12.8	11.2	10.3	10.6	11.6	11.2	9.7	9.1	10.7	8.6	11.7	11.4	13.9	17.4	19.2	23.5	28.0	25.6	36.1	327.6
17.3	15.6	14.2	14.5	14.7	13.8	14.3	12.8	12.2	11.1	11.6	9.5	13.5	13.4	17.3	24.6	29.4	37.2	48.1	46.7	75.3	464.1
27.5	21.9	18.3	15.6	14.2	13.5	13.4	12.3	12.9	11.5	11.4	9.3	12.6	11.9	14.0	17.8	22.6	32.0	33.7	30.1	47.9	404.5
19.7	18.2	15.9	14.6	12.8	13.7	13.8	13.1	13.8	13.4	12.6	10.8	13.7	14.2	18.1	24.9	30.3	37.5	43.7	57.6	79.3	491.5
20.1	15.4	12.5	11.7	10.5	11.1	12.3	11.6	12.3	11.0	10.9	8.4	11.1	11.3	13.4	18.1	19.7	23.2	38.4	44.0	43.0	370.0
24.1	21.3	19.8	17.5	13.6	12.2	12.8	12.8	14.3	9.9	11.4	9.2	21.6	20.0	24.1	25.8	28.4	33.8	43.9	80.7	55.7	512.9
18.2	15.2	12.9	12.2	11.3	11.6	12.5	12.2	13.2	11.6	11.6	10.0	14.2	13.6	18.0	22.5	31.0	36.1	35.8	43.2	53.4	420.3
20.1	19.0	16.7	14.8	13.3	14.0	14.3	12.0	12.3	10.7	10.5	9.5	11.3	11.6	14.8	16.7	16.7	24.3	26.7	34.8	38.9	363.1
20.4	17.8	16.2	15.3	14.8	15.7	11.7	10.7	11.6	10.7	11.8	9.3	13.0	14.7	15.7	17.5	18.9	22.8	30.1	29.5	31.9	359.8
47.5	53.7	38.8	13.2	12.1	10.6	11.9	12.9	13.9	12.3	12.5	10.1	12.6	13.3	14.0	17.3	17.7	21.5	36.2	49.8	58.8	490.6
25.9	23.9	14.3	12.2	11.7	10.8	11.4	11.2	11.8	10.8	11.5	8.8	12.9	16.5	23.7	27.7	37.6	31.3	40.3	46.6	47.0	448.0
38.0	35.4	26.3	27.4	22.7	20.0	17.1	15.1	15.8	14.5	14.0	12.9	22.5	20.3	16.6	18.8	21.2	30.2	35.2	34.8	41.3	504.0
21.2	18.2	15.7	13.8	12.1	12.7	13.6	13.9	13.3	11.6	11.5	7.8	10.3	10.4	11.9	16.7	17.0	18.8	24.8	25.8	35.4	335.4
19.8	18.2	16.7	14.9	13.1	13.1	13.4	13.4	13.7	13.2	11.7	9.8	13.0	13.0	15.8	18.6	24.2	22.3	28.5	28.5	31.2	365.1
23.4	19.1	14.7	12.9	12.0	12.5	13.6	12.6	13.4	12.1	12.5	10.0	12.9	13.3	17.8	18.2	20.8	22.7	33.3	36.7	45.8	390.4
22.7	21.9	18.7	17.9	14.4	14.1	14.1	13.5	14.3	12.4	11.1	10.1	12.8	12.7	14.4	17.0	23.1	26.2	30.9	37.1	43.2	402.5
23.4	19.4	17.3	14.7	14.1	12.7	12.9	13.3	14.2	15.9	14.2	11.2	14.1	17.6	24.0	24.4	26.8	29.2	31.9	31.6	54.5	437.2
56.3	51.8	45.1	34.2	12.9	13.3	14.3	14.0	14.9	13.4	13.3	10.7	14.2	15.0	17.2	21.4	21.3	23.4	71.1	59.8	61.5	598.9
14.0	11.7	10.4	9.5	9.3	9.8	12.3	12.0	13.1	12.1	12.0	10.0	13.1	13.3	14.9	18.0	21.4	29.2	37.4	41.7	46.5	371.7

Annual Yield and dependable flow at Sirkari-Bhyol Rupsiabagar HE Project

Year	Total availability (monsoon + non-monsoon) (MCM)	Descending (MCM)	Rank	Probability
1977-78	1154.4	1971.8	1	2.56%
1978-79	1041.5	1632.1	2	5.13%
1979-80	770.2	1534.5	3	7.69%
1980-81	924.2	1421.7	4	10.26%
1981-82	1201.4	1420.5	5	12.82%
1982-83	1215.0	1418.0	6	15.38%
1983-84	1253.4	1399.8	7	17.95%
1984-85	1174.6	1388.5	8	20.51%
1985-86	1173.0	1388.3	9	23.08%
1986-87	994.2	1385.4	10	25.64%
1987-88	985.9	1376.7	11	28.21%
1988-89	1061.4	1361.6	12	30.77%
1989-90	1360.6	1360.6	13	33.33%
1990-91	1343.5	1359.7	14	35.90%
1991-92	1361.6	1343.5	15	38.46%
1992-93	1399.8	1337.3	16	41.03%
1993-94	1289.1	1310.8	17	43.59%
1994-95	1262.6	1305.6	18	46.15%
1995-96	1388.5	1289.1	19	48.72%
1996-97	1162.6	1281.7	20	51.28%
1997-98	1268.8	1268.8	21	53.85%
1998-99	1359.7	1262.6	22	56.41%
1999-00	1388.3	1253.4	23	58.97%
2000-01	1281.7	1248.8	24	61.54%
2001-02	1385.4	1215.0	25	64.10%
2002-03	1305.6	1201.4	26	66.67%
2003-04	1337.3	1190.3	27	69.23%
2004-05	1190.3	1174.6	28	71.79%
2005-06	1534.5	1173.0	29	74.36%
2006-07	1418.0	1162.6	30	76.92%
2007-08	1632.1	1155.0	31	79.49%
2008-09	1248.8	1154.4	32	82.05%
2009-10	1155.0	1061.4	33	84.62%
2010-11	1420.5	1041.5	34	87.18%
2011-12	1421.7	994.2	35	89.74%
2012-13	1376.7	985.9	36	92.31%
2013-14	1971.8	924.2	37	94.87%
2014-15	1310.8	770.2	38	97.44%

50% dependable yield	1285 MCM
75% dependable yield	1170 MCM
90% dependable yield	993 MCM

Annexure – III: Copy of Letter submitted to CWLW for approval of Conservation plan for Schedule-I species

Recieved copy

यूजेवीएन लिमिटेड

(उत्तराखण्ड सरकार का उपक्रम)

कार्यालय–महाप्रबन्धक (सिविल डिजाइन एण्ड हाइड्रोलोजी एवं नई परियोजनायें), गंगा भवन, यमुना कालोनी,
देहरादून–248001 (उत्तराखण्ड), दूरभाष: 0135–2531700, फैक्स सं०: 0135–2530489

ISO 9001:2008 Certified

पत्रांक: 51 / यूजेवीएनलि / 03 / निदे.(परि.) / मप्र(नई परियोजना) / एसबीआर दिनांक: 02.03.2021

सेवा में,

मुख्य वन्य जीव प्रतिपालक
वन विभाग,
85, राजपुर रोड
देहरादून, उत्तराखण्ड।

विषय: सिरकारी भ्योल रूपसियाबगढ़ जल विद्युत परियोजना (120 मेगावाट) के परियोजना क्षेत्र में पाये जाने वाले Schedule I species के संरक्षण हेतु योजना के सम्बन्ध में।

सन्दर्भ: प्रभागीय वनाधिकारी, पिथौरागढ का पत्रांक संख्या 3185 / 12–1 दिनांक 25.02.2021

महोदय,

उपरोक्त विषयक आपको अवगत कराना है कि पिथौरागढ जिले में स्थित सिरकारी भ्योल परियोजना के विकास हेतु पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार द्वारा निर्गत ToR के आधार पर निर्मित पर्यावरणीय प्रभाव आंकलन एवं पर्यावरणीय प्रबन्धन योजना तैयार की गयी है। दिनांक 05.02.2021 को उक्त रिर्पोट का पर्यावरणी स्वीक्रति हेतु पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय द्वारा गठित विशेषज्ञ मूल्यांकल समिति, के समक्ष प्रस्तुतिकरण किया गया (बैठक के कार्यवृत्त की छायाप्रति संलग्न)।

विशेषज्ञ मूल्यांकल समिति द्वारा यूजेवीएन लि० को निम्न बिन्दु पर अनुपालन करने हेतु निदेशित किया गया है:–

point 4. Conservation plan for schedule I shall be prepared and submitted to the Chief Wildlfife Warden for approval.

अवगतनीय है कि यूजेवीएन लि. द्वारा परियोजना हेतु निर्मित वन्यजीव एवं जैवविविधता प्रबन्धन योजना तैयार की गयी है जिसमे परियोजना क्षेत्र में पाये जाने वाले वन्यजीवां के संरक्षण हेतु प्राविधान सम्मिलित हैं। उक्त योजना हेतु रू 99.0 लाख का प्राविधान किया गया है जिस पर उक्त संदर्भित पत्र के माध्यम से प्रभागीय वनाधिकारी द्वारा सक्षम प्राधिकारी की संस्तुति के उपरान्त अनुमोदन प्रदान किया जा चुका है।

परियोजना हेतु निर्मित वन्यजीव एवं जैवविविधता प्रबन्धन योजना संलग्न कर अग्रिम कार्यवाही हेतु प्रेषित है।

संलग्नक: उपरोक्तानुसार

(ओ० पी० सिंह)
महाप्रबन्धक (जानपद–नई परियोजनायें)

पत्रांकः /यूजेवीएनलि/03/निदे.(परि.)/मप्र(नई परियोजना)/एसबीआर तददिनांक

प्रतिलिपि निम्नलिखित को सूचनार्थ प्रेषितः–

4 निदेशक (परियोजनायें), यूजेवीएन लिमिटेड, महारानी बाग, देहरादून।
5 उपमहाप्रबन्धक, सिरकारी भ्योल रूपसियाबगढ़ जल विद्युत परियोजना, कैन्ट रोड, जाखनी, पिथौरागढ।
6 उपमहाप्रबन्धक (अनु. एवं नियोजन तथा किसाऊ परियोजना), गंगा भवन, यमुना कालोनी, देहरादून।

(ओ0 पी0 सिंह)
महाप्रबन्धक (जानपद–नई परियोजनायें)

पत्रांक-F.No 9/81/127 दिनांक 03/03/2021

प्रतिलिपि-प्रभागीय वनाधिकारी, पिथौरागढ़ वन प्रभाग, पिथौरागढ़ को सह संलग्नक इस आशय के प्रेषित कि Conservation Plan का नवीनतम अद्यतन कर उक्त Plan पर हस्ताक्षर उक्त वर्णित प्रेषित करें।

संलग्नक - यथोपरि।

मुख्य वन्यजीव प्रतिपालक
उत्तराखण्ड, देहरादून
3/3/21

कार्यालय प्रभागीय वनाधिकारी, पिथौरागढ़ वन प्रभाग, पिथौरागढ़।

E-mail: dfopithoragarh@rediffmail.com Fax &☎ 05964- 225234

पत्रॉक 3703 /12-1 दिनांक, पिथौरागढ़, 18 मार्च, 2021।

सेवा में,

मुख्य वन्यजीव प्रतिपालक,
उत्तराखण्ड, देहरादून।

विषयः– सिरकारी भ्योल रूपसियाबगड़ जल विद्युत परियोजना (120 मेगावाट) के परियोजना क्षेत्र में पाये जाने वाले **Schedule I species** के संरक्षण हेतु योजना के सम्बन्ध में।

सन्दर्भः – आपका पत्रांक–**R.No. 9181/12-1** दिनांक 03.03.2021।

महोदय,

उपरोक्त सन्दर्भित पत्र के अनुपालन में सादर अवगत कराना है कि यूजेवीएन लिमिटेड द्वारा प्रस्तावित एवं अधोहस्ताक्षरकर्ता को प्रस्तुत सिरकारी भ्योल रूपससियाबगड़ जल विद्युत परियोजना (120 मेगावाट) की EAI & EMP रिपोर्ट के सैक्शन 10.4 में निहित Wild Life and Biodiversity Management Plan का भली भॉति अध्ययन कर सम्यक विचारोपरान्त निम्नवत् अनुमोदित किया गया।

क्रम सं0	सन्दर्भ	प्रस्तावितप्राक्कलन रू0 लाख में	अनुमोदिलप्राक्कलन रू0 लाख में
1-	Table 10.24: Cost under Conservation Plan	65.00	68.00
2-	Table 10.25: Estimated cost of Biodiversity Conservation and Management Plan.	95.00	99.00

यूजेवीएन लिमिटेड द्वारा प्रस्तुत Wild Life and Biodiversity Management Plan अधोहस्ताक्षरकर्ता द्वारा हस्ताक्षरित एवं मुहर सहित आपके अवलोकनार्थ एवं अग्रिम आवश्यक कार्यवाही हेतु संलग्न है।

संलग्नकः यथोपरि।

भवदीय,

प्रभागीय वनाधिकारी,
पिथौरागढ़ वन प्रभाग, पिथौरागढ़।

प्रभागीय वन अधिकारी
पिथौरागढ़ वन प्रभाग
पिथौरागढ़

WILDLIFE AND BIODIVERSITY MANAGEMENT PLAN

OF

Sirkari Bhyol Rupsiabagar HEP (120 MW)

District Pithoragarh,

Uttarakhand

Sector 1 (c) (i), Category A

January 2021

Submitted by:

Uttarakhand Jal Vidyut Nigam Ltd.

Maharani Bagh, Dehradun

Uttarakhand

अधिशासी अभियन्ता (जानपद)
सि०म्यो०रुप०परि०, यू जे वि एन लि०
मुन्स्यारी, पिथौरागढ

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मन्स्यारी, पिथौरागढ़

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1.1. Wildlife and Biodiversity Management Plan

1.1.1. Introduction

The main objective of Biodiversity Conservation and Management plan is sustainable use of natural resources, which involves scientific management of natural wealth vis-à-vis developmental activities, is likely to affect these resources. The threats to natural terrestrial and aquatic ecosystems generally arise due to by anthropogenic activities that may arise because of construction and associated activities of proposed HEP Scheme. A detailed biodiversity conservation and management plan has been proposed and the main objectives of said plan are as follows:

- Maintenance of ecological balance through preservation and restoration of wherever it has been disturbed due to project developmental activities,
- Conservation and preservation of natural habitats in catchment area
- Rehabilitation of critical species (endangered, rare and threatened species), if any with provisions for *in-situ* or *ex-situ* conservation of critical/ important plant/ animal species,
- Mitigation and control of project induced biotic and/or abiotic pressures/influences that may affect the natural habitats,
- Habitat enhancement in project catchment area by taking up afforestation and soil conservation measures,
- Creating all round awareness regarding conservation and ensuring people's participation in the conservation efforts and minimizing man animal conflict.

1.1.2. Protected Areas

No National Park, Sanctuary, Notified Eco-sensitive areas protected under Wild Life (Protection) Act exists within the project area or within 15 km distance from it

1.1.3. Conservation of Rare, Endangered & Threatened species.

During the course of primary survey only one plant species (*Taxus wallichiana*) was recorded as RET in the study area. The propagation and cultivation method for this species has been standardized by the State Forest Department, consulting with Forest Research institute. The planting of this purpose may be produced by seed germination or any other conventional methods instead of tissue-cultured plants for mass multiplication to save genetic diversity. The cost of afforestation for this species in an area of 1.0 ha @ Rs. 5lakh/ha would be Rs. 5.00 lakh only.

1.1.4. Conservation and Cultivation of Medicinal Plants

An herbal nursery shall be developed at an appropriate location. Farmers shall be trained to make them aware of the use of herbal plants and in animal health care also. For creating one herbal garden in 2 ha area a sum of Rs. 10.00 lakhs have been earmarked. The work under Wildlife & Biodiversity Management Plan shall be carried out by the Forest Department. Herbal garden shall be developed in forest land and shall be an activity related to conservation development of forest for which no diversion of forest land is involved.

1.1.5. Endemic, Threatened and Endangered species of mammals

The Indian Wildlife Protection Act (1972) also scheduled the animals in various categories for giving them varying degree of protection. Among recorded mammals, three species viz., Bharal, Himalayan Thar and Indian Wolf, have been reported as Schedule I species. Thus, for conservation of these wild animals a management plan has been formulated.

1.1.5.1 *Conservation Plan:*

The people living in the surrounding area and employee of the company would be motivated towards the protection of the animal. Motivation will lead to timely information to the concerned authorities about any threat to wild life or any cases of poaching/hunting. Proper incentive shall be given to such locals who pass on information about the illegal poaching. Water holes should be made away from such places where the local people bring their animals for grazing. The ban on use of plastic bags should be strictly followed. The dangerous chemicals should not be indiscriminately disposed near to the water holes otherwise the water quality shall be impaired to dangerous proportion. The database of natural habitat of wild animals should be prepared and the information disseminated to the gram Panchayat. A great deal of wildlife also inhabits the area outside of the forests which do not fall under jurisdiction of the Forest Department. In context of such areas the revenue department and the NGOs may take joint and concerted efforts for protection of animals. The following conservation measures are proposed.

- Conservation of Soil and Improvement of Water Regime
- Habitat Improvement
- Creation of Conservation awareness
- Provision of Salt Lakes
- Incentives to Informers of Illegal hunting /poaching of animals
- Fencing of natural habitat to check the encroachment of shrinking habitat
- Strengthening of translocation centres of the district by one-time financial aid.

1.1.6. Conservation Plan for Grey Wolf

Figure 1.1 : Photograph of Grey Wolf

Kingdom: Animalia, Phylum: Chordata, Class: Mammalia, Order: Carnivora, Family: Canidae

Genus: Canis, Binomial Name: Canis lupus

Description: A large canid, the Grey Wolf superficially looks like a slim Alsatian (Iljin, N.A, 1941) with a big head, long limbs, large feet, a slightly curved tail and shorter ears. It has a long muzzle. Its pelage varies greatly with tones of red and grey fur intermingled with black, especially on the dorsal crest, forehead and tip of the tail. The undersides are buff or creamish in colour. Despite being one of the largest canids of the Indian Subcontinent, the Indian Grey Wolf is smaller than the subspecies found in Europe and America. The peninsular subspecies has lesser under fur and has whither lower limbs than other subspecies. The 'V' on the back is of a darker colour. In summer pelage, the coat is much redder and shorter as the longer black and grey fur is shed. Winter pelage is thicker. In contrast, the Tibetan Wolf has much more under fur and is completely black in colour.

Behaviour: Gray wolves are highly social, pack-living animals. Each pack comprises two to thirty-six individuals, depending upon habitat and abundance of prey. Most packs are made up of 5 to 9 individuals. Packs are typically composed of an alpha pair and their offspring, including young of previous years. Unrelated immigrants may also become members of packs.

There is a strong dominance hierarchy within each pack. The pack leader, usually the alpha male, is dominant over all other individuals. The next dominant individual is the alpha female, who is subordinate only to the alpha male. In the event that the alpha male becomes injured or is otherwise unable to maintain his dominance, the beta male will take his place in the hierarchy. Alpha males typically leave the pack if this occurs, but this is not always the case. Rank within the pack hierarchy determines which animal mate and which eat first. Rank is demonstrated by postural cues and facial expressions, such as crouching, chin touching, and rolling over to show the stomach.

Distribution: It is distributed form the eastern parts of the Kashmir Valley to the Changthang in Ladakh. Jammu & Kashmir; a small population is known from Spiti in Himachal Pradesh. It is distributed in a patchy fashion through peninsular India in appropriate habitat. It is mainly found in the states of Haryana Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and West Bengal. The species is absent in the Western Ghats as well as the Himalayan foothills and Terai (Jhala and Giles, 1991) and probably in north-east India.

Habitat: It inhabits cold deserts of the trans-Himalayas while it frequents dry open country, scrubland and semi-arid grasslands in the peninsula (Jhala and Giles, 1991). It has a wide tolerance level of habitat with different precipitation as is evidenced by its presence in habitats with 300 mm precipitation in the Rann and in parts of Rajasthan, to those with 1,500 mm precipitation in Odisha. (Shahi, 1982)

Conservation Status: The Grey Wolf is listed as List Concerned species in the Red List of International Union for Conservation of Nature (IUCN) and Appendix-I and II in CITES. As far as the Indian Wildlife Protection Act, 1972 is concerned; the species is placed in Schedule-I.

Threats: Their original worldwide range has been reduced by about one-third, primarily in developed areas of Europe, Asia, Mexico, and the United States by poisoning and deliberate persecution due to depredation on livestock. Since about 1970, legal protection, land-use changes, and rural human population shifts to cities have arrested wolf population declines and fostered natural recolonization in parts of Western Europe and the United States, and reintroduction in the western United States. Continued

threats include competition with humans for livestock, especially in developing countries, exaggerated concern by the public concerning the threat and danger of wolves, and fragmentation of habitat, with resulting areas becoming too small for populations with long-term viability.

Conservation Steps: The purpose of the conservation plan of Grey wolf is to maintain a favorable status for the wolf population in project area for an unlimited period of time and to promote the maintenance of a favorable status of the wolf population without specifying the maximum number of individuals and habitats, but ensuring the presence of wolves as a united and functional component. Following steps shall be incorporated for species conservation and management.

- Promotion of a positive attitude (public and employee of project) towards the presence of wolves at the landscape level and within a context of wildlife diversity, to reduce the attitude to this species as an unwanted competitor or an unacceptable obstacle to economic activity.
- Conflicts involving attacks of large carnivores on livestock are to be reduced by providing advisory and financial support to livestock owners, as well as by a convenient system and procedures for detecting and recording damages.
- Management of other wildlife species and forests is conducted in a way that wolf functional activities in the ecosystem (foraging, breeding and habitat selection, dispersal) are kept as close to natural as possible.
- Public education and raising awareness on wolf conservation issues is to be continued.

1.1.7. Conservation Plan for Bharal

Figure 1.1 : Photograph of Bharal

Kingdom: Animalia, Phylum: Chordata, Class: Mammalia, Order: Artiodactyla, Family: Bovidae

Genus: Pseudois,

Species: *P. nayaur*

Binomial Name: *Pseudois nayaur*

Description: Bharal (Blue Sheep) is a goat-like caprid. Bharal is stockily built, stout-legged and broad-chested, designed for living in precipitous and rocky terrain. HBL: 120-140 cm, HAS: 80-91.4 cm. (male) HL: 38-76 cm.(male) 10-20 cm (female) Weight: 60-75 kg (male) and 35-55 kg (female). Adult male Bharal have a slate blue coat. In winter, this colouration becomes more pronounced, while in summer the coat becomes red brown especially in females and young, serving as better camouflage. The trans Himalayas rams tend to achieve a light almost cream, colouration while in Himalayas the colour is much darker. Adult rams in both areas have dark brown to black markings on the neck. The tail is short and dark. The male's horn is very characteristic and curve outward, backward and then downward in a crescent formation. Females are one –third the size of the males, have much shorter and thinner horns that diverge out are dull shale in colour and have dark grey instead of black markings on their body.

Behaviour: Solitary animals are common and herds mostly occur in medium sized group of 10-15, sexes usually segregate in summer when males mostly occur in all male groups and females and young separate into more secure areas. During rut, males rear up and strike each other like goats. However, they court females by raising their forelegs and stretching out their head in sheep like fashion, they may mouth their own red penis as a threat display but they may rub their face on the rival's backside in appeasement.

Food and Feeding:

Bharals can obtain food resources from sparse, high-elevation vegetation. Some plant taxa eaten by Bharal comprise: *Arundinella sp., Danthonia sp., Festuca sp., Trisetum sp., Berberis, Cotoneaster, Ephedra, Lonicera, Juniperus, Poa alpina, Poa pratenis.*

Longevity and Mortality: 12-15 years in zoos, in the wild, animals older than 10 years are rarely encountered. Major mortality occurs in winter and spring due to climatic conditions and poor forage quality.

Distribution: The Greater Himalayan meadows and trans Himalayan regions in India from Jammu & Kashmir to Arunachal Pradesh. Along with serow, has the largest distribution of a Himalayan mountain ungulate in India.

Habitat: Bharals occupy a variety of habitats across the region with highly variable annual precipitation. They inhabit open grassy slopes in high mountains from 2.500-5.500 masl. Bharals are usually found near cliffs and similar escape cover, and generally avoid entering forests (Schaller 1977; This species is often able to maintain locally high densities in habitats otherwise inhospitable to other wild species. Often, these areas are close to domestic livestock (although generally at higher elevations, or in less productive habitats). They are very tolerant of environmental extremes from desert mountains in searing heat to windy and cold slopes (Schaller 1998). Nevertheless, Bharals choose better habitat if available. Temperate and subalpine forests precipitous terrain with grass cover and slopes with oak and bamboo forests. In the Greater Himalayas, found on southern forested slopes (1550-5300 masl although they prefer higher altitudes between 2000-4400 masl)

Conservation Status: The IUCN Red List classifies the Bharal as "least concern "in view of its wide distribution, presumed large population, and because any decline is probably much less than the rate required to qualify for listing in a threatened category. As far as the Indian Wildlife Protection Act, 1972 is concerned; the species is placed in Schedule-I. In India, Bharal occur in several National parks and many other protected areas in Northern India (Fox 1987; Fox et al. 1986, 1991; Gaston et al. 1981, 1983; Green 1987; Pandey in prep.; Singh et al. 1990) including Jammu and Kashmir – Hemis National Park and Sabu Chukor Wildlife Reserve; Himachal Pradesh – Great Himalayan and Pin Valley National Parks and Chital, Daranghati, Kais, Kanawar, Lippa Asrang, Rakshum, Rupi Bhaba, Sangla Valley (includes previous Rakcha-Chitkul WS), Sechu Tuan Nala, and Tirthan (locally threatened) Wildlife Sanctuaries; Uttarakhand – Nanda Devi and Valley of Flowers National Parks, and Govind Pashu Vihar and Kedarnath Wildlife Sanctuaries; Sikkim – Khangchendzonga National Park.

Threats: Competition with livestock has been suggested and probably occurs (Shrestha et al. 2005), but in general, habitat loss due to livestock threat is minor. They can sustain a reasonably large population under current and likely future scenarios with regard to the livestock industry. This is because reasonably large populations of the species can be supported entirely within high elevation, steep, or excessively rough/rocky terrain that is used sparingly if at all by domestic livestock. Livestock does exist near P. nayaur sub populations, and in specific situations there may be conflicts. However, in general, it appears that even relatively intensive livestock grazing does not prohibit healthy populations of Bharal. This is in marked contrast to livestock's effect on some other wild species.

Bharals are hunted for food. But because access to Bharal habitat is usually difficult and individual body-size is relatively small, market-based poaching for meat appears to be rare. Locally-based, subsistence poaching has occurred frequently in recent years, and no doubt continues.

Conservation Steps: Following steps shall be incorporated for species conservation and management.

- Make the control of illegal hunting of this species the primary management priority to maintain viable populations under current land use regimes.
- Monitor changes in livestock grazing practices that could affect competition with Bharal
- Steps should be taken to halt or reverse the habitat destruction caused by livestock grazing in Bharal's natural habitat.
- Public education and raising awareness on Bharal conservation issues is to be continued. The target audience consists of professionals from state administration authorities and project's administration, environmental NGOs, education and tourism sectors, as well as hunters and farmers

1.1.8. Conservation Plan for Himalayan Tahr

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Figure 1.1 : Photograph of Himalayan Tahr

Kingdom: Animalia, Phylum: Chordata, Class: Mammalia, Order: Carnivora, Family: Bovidae

Genus: Hemitragus

Species: *H. jemlahicus*

Binomial Name: *Hemitragus jemlahicus*

Description: *Hemitragus jemlahicus* has relatively short legs and a small head. Males are large than females. Males average 73 kg in weight while females average 36 kg. Their hooves are well-adapted for their mountain habitat, with a hard rim of keratin surrounding a soft spongy convex pad. These hooves and strong dewclaws allow them to be excellent climbers.

The adult male in winter has a dark face and muzzle, sides and hindquarters black to red-brown, a reddish rump patch, and a lighter underside. It has a thick ruff or mane around its neck and shoulders and down its front legs. Older males are darker, with a light band along the flanks and a dark mid-dorsal line. The mane may be as long as 250 cm and is slate grey to straw-coloured. The adult female in winter is grey to brown with a darker muzzle and legs and a light underside. The summer coat in adults of both sexes is shorter and lighter brown to straw-coloured. Young are uniformly brown except for the front of their legs, which are black.

Both sexes have horns which curve up, back, and then in. They are laterally flattened, triangular in cross-section, and have a keel on the front edge. Males have longer horn (up to 450 mm) than females (up to 190 mm).

Behavior: These are most active in the early morning and late afternoon, 3-4 hours post-dawn and pre-dusk. It spends over half the daylight hours resting. It has a daily vertical migration, moving upslope in the morning, resting there in the middle of the day, and moving downslope for the night. These live-in herds of 2-23 animals. Outside of the breeding season, males usually live in separate groups from females and young (under 2 years old), with males older than four years often separate from younger

males. Groups that include males are larger than all-female groups. There is no apparent dominance hierarchy within groups.

Food and Feeding:

The Himalayan Thar is primarily a grazer, feeding mainly on grasses, sedges, herbs, ferns and mosses. Food plants of the thar in Langtang included shrubs such *as Berberis concinna, Caragana nepalensis, Cotoneaster microphylla, Juniperus wallichiana and Rhododendron lepidotum*; grasses such as *Danthonia schneideri, Festuca ovina, F. gigantea* and Poa pagophila; sedges such as *Carex* and *Kobresia spp.*; herbs such as *Iris decora, Potentilla pendunculata, Primula aureata* and *Rheum moorcraftianum*; and the fern *Dryopteris sp.* (Green 1978). In eastern Nepal, tahr were observed feeding on *Danthonia schneideri, Cymbopogon thwaitesii, Arundinella nepalensis* and other grasses, and occasionally on the leaves of the oak (*Quercus spp.)* and montane bamboo (*Thamnocalamus spp., Chimnobambusa spp.).* About 75 per cent of the tahr's diet was made up of grasses, 7 per cent of twigs and leaves, 6 per cent of montane bamboo and 4 per cent forbs and also lichen (Schaller 1973). Tahr have been observed to rise up on their hind legs to browse or to reach grasses and mosses growing in otherwise inaccessible rocky areas. They also lick crustose lichen off rocks, dig for roots in winter and lick soil for salt or consume grit (Schaller 1973, Green 1978, S Sathya kumar pers. observ.). Tahr take in sufficient moisture with fodder, but during dry periods, they may drink water from streams (Green 1978).

In the Tung Nath region of Kedarnath Wildlife Sanctuary, during the investigations on thar–livestock interactions in 2002–03, Kittur et al. (2010) reported that the diet of thar was composed mainly of graminoids (53.3%) and forbs (43.2 %). Ferns and other monocots comprised only a small part of the diet. The percentage of grasses and sedges was much lower in winter than in other seasons. For the thar, consumption of dicots increased in autumn (49.7%) and peaked in winter (68%); consequently, the proportion of grasses and sedges in the diet decreased in autumn (from 24 % to 22.7 %) and winter (from 16% to 13 %).

Longevity and Mortality: Normal lifespan is 10-14 years, although individuals up to 22 years old have been reported. Females live longer than males. Accidental death due to rock slides or avalanches is not uncommon

Reproduction: In the Himalayas, the rut runs from mid-October to mid-January. In New Zealand, the rut runs from April to July and peaks in May or early June. The difference in breeding season is due the six-month shift in seasons between the northern and southern hemispheres. During the rut, younger males will follow groups of females and attempt, generally unsuccessfully, to mate with any female. Older males will follow and defend individual oestrus females. The mating display consists of a male standing facing a female, at a right angle to her, with his head and muzzle high and his mane erect and hiding his horns. This is followed by a series of head nods and brief copulation. The competitive display involves two males walking stiffly parallel to each other, with their mane and dorsal ridge erect, their heads down, and their horns exposed. The victor will either move to block the path of his opponent or chase him away. Only rarely does the competitive display led to direct head-to-head wrestling, which in *Hemitragus jemlahicus* has been described as "half-hearted" relative to other horned or antlered mammals.

Females leave their groups to give birth. The kid is able to nurse within a few minutes and can walk within three hours. Mother and kid return to the group after a few days.

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Twins are very rare in the wild, but occur more frequently in captivity. In the Himalayas, births occur from mid-April to mid-July.

Distribution: Hemitragus jemlahicus is native to the southern flanks of the Himalaya Mountains from northern India east to Bhutan, as far north as Tibet. It has been widely introduced elsewhere for hunting. After introduction to New Zealand in 1904 it spread to all the suitable habitat there. There are also introduced populations in New Mexico, California, Ontario, and South Africa.

Habitat: In the Himalayas, *Hemitragus jemlahicus* prefers rugged wooded hills and mountains slopes in the subalpine and alpine regions from 3500-4500 meters in elevation. It may also seasonally use mixed oak forests as low as 2500 meters and alpine meadows as high as 5000 meters.

Conservation Status: The Himalayan Tahr is listed as Near Threatened species in the Red List of International Union for Conservation of Nature (IUCN). As far as the Indian Wildlife Protection Act, 1972 is concerned; the species is placed in Schedule-I.

Within India, the Himalayan Thar is now distributed from the Bani and Badherwah areas near Jammu in Jammu and Kashmir in the west, to western parts of Khangchendzonga National Park in Sikkim in the east. In Himachal Pradesh, where legal hunting was permitted until the early 1980s, Thar populations are recovering in a few isolated pockets, for instance, in the Chamba and Kullu districts. Similarly, in Uttarakhand, with the exception of a few well-protected areas such as Nanda Devi National Park and Biosphere Reserve and Kedarnath Wildlife Sanctuary, Thar occurs in low densities (Sathya Kumar 2006, Kandpal and Sathya Kumar 2010, Kittur et al. 2010).

Conservation Steps: Following steps shall be incorporated for species conservation and management.

- Make the control of illegal hunting of this species the primary management priority to maintain viable populations under current land use regimes.
- Increased protection of the Himalayan Thar and its habitat, creating general awareness, wildlife research and management are an absolute necessity for the conservation of this species.
- Wildlife viewing as a part of 'eco-tourism' in the Himalaya should be encouraged, particularly observing animals such as the Himalayan Thar.
- Local villagers who are skilled at observing thar and/or other wildlife could be trained as 'eco-guides' and gainfully employed.
- Apart from economic returns, local villagers would realise the importance of such species and help in their protection for the purpose of long-term sustainability of eco-tourism.

1.1.9. Strategies for Conservation of Schedule-I Wildlife:

The buffer areas are essential for ensuring forest connectivity for these animals and land tenure dynamic as these constitute habitats for sub-adult, transients and old members of the Wildlife population. The aging wild animals from the source population residing in core zone migrate to the buffer zone while the adult replace them in source population zone (core zone). With habitat depletion of the buffer area, the source population shall be easily targeted and will always be at the risk of being eliminated. The buffer / fringe areas have immense importance as they have high corridor value which calls for maintaining and improving their ecological sustainability. Otherwise, they are likely to become ecological source sinks.

Forest areas can be developed as wildlife habitat by resorting to restorative strategies which *inter alia* would into the following:

1. Redressing man animal conflict
2. Habitat improvement measures
3. Anti-poaching operations
4. Capturing problematic and aberrant animals
5. Staff development and capacity building

Redressing Man Animal Conflict

The villages near forest have small chunk of agricultural land and people are mainly depending upon rain fed crops. Wild animals like often damage their crops which is the main man-animal conflict around the area. Though Wildlife (Protection) Act, 1972 authorizes Chief Wildlife Warden and Officers acting on his behest to permit killing of such wild animals causing destruction to life and property, yet the local due to religious sentiments do not opt for animal killings. In such a scenario adequate compensation shall be made to suffering stake holders near the buffer areas. To avoid revenge killing the compensation in case of loss of human life, resulting from man-animal conflict, shall be made @ Rs. 2.0 lakh / victim while for serious injuries Rs. 0.6 lakh / person.
Besides this crop protection structures can be erected at prominent places and cages/traps to catch problematic animals can be deployed.

Habitat Improvement Measures

The activities under this sub-head mainly comprises of such initiative which will improve the forage and browse values of the habitat for wild animals. The works like creating water holes, water retaining structures, pastureland reclamation (grass improvement) and eradication of weeds. The improvement in the floral diversity in the buffer area can be partly achieved from plantation under green belt to be carried out under the environment management plan proposed under the EIA/EMP report.

Anti-Poaching Operations

Under this sub-head deployment of anti-poaching squads drawn from army personnel and home guard; deployment of special tiger protection force (STPF) shall be the main constituent of the plan. Besides this establishment and maintenance of patrolling camps/ chokies equipped with wireless sets/mobile phones and procurement of field gear, night vision devices shall be the other ingredients.

Capturing problematic and aberrant animals

This will involve procurement and deployment of traps, cages to catch aberrant animals besides procurement of tranquilizing equipment.

Staff development and capacity building

Under this sub-head specialized training in the field of management planning, park interpretation through conducting workshops / seminars / study tours for appraisal of good practices followed in other reserves. Apart from this training in the use of GIS systems and anti-poaching operations shall be imparted.

1.1.9.1 *Financial Projection of Conservation Plan*

To implement the conservation, plan following works are proposed within forest and civil forest. More emphasis will be given to soil and water conservation structures and creation of water holes along with the habitat development works. To improve the habitat and conserve the flora and fauna following items of works are proposed and tentative financial allocation for the same is given in **Table 1.1**.

Biodiversity Conservation and Management Plan has to be implemented by the Forest Department, as a deposit work, for which the project proponent shall make the funds available in installments to the user agency and the user agency shall submit certificate of yearly utilization. Since the plan has to be implemented by the Forest Department, the various ingredient of plan and their financial aspects have to be wetted by DFO, Pithoragarh, vide letter No.1051/12-1 dated 14.9.2020. **(Annexure-III)**

Table 1.1 : Cost under Conservation Plan

S. No.	Item	Amount (Rs. Lakh)
1. Conservation of Soil and Water		
1.1	Improvement of existing water sources (Small Ponds)	2.00
1.2	Development of new water sources (Water Holes)	2.00
1.3	Construction of Anicut / Check Dams on small Nalas	3.00
2. Habitat Improvement		
2.1	Plantation / Pasture Development	20.00
2.2	Burning regime, seeding and grass cutting	5.00
2.3	Improvement of Escape cover	2.00
2.4	Improvement of Reproductive cover	7.00
3. Creation of Conservation Awareness		3.50
4. Provision of Salt Licks		0.50
5. Incentives to informers of illegal game / poaching		5.00
6. Fencing of Natural Habitat to check the encroachment		5.00
7. Compensation for loss of human life, resulting from man-animal conflict		10.00
8 Motor Bikes for patrolling by Front Line Staff (Forest Guard and Forester)		3.00
Total		**68.00**

1.1.10. Cost Estimates

Table 1.2 shows the overall cost of works under the plan. Funds to the tune of **Rs. 99.00 lakh** shall be allocated to the forest department for implementing plan. The Plan is approved by DFO, Pithoragarh, vide letter No.1051/12-1 dated 14.9.2020 **(Annexure).**

Table 1.1 : Estimated cost of Biodiversity Conservation and Management Plan

S. N.	Item	Amount (Rs. Lakh)
1	Conservation of Rare, Endangered & Threatened species of plants	5.00
2	Medicinal Plants Cultivation and Conservation	5.00
3	Development of herbal garden	10.00
4	Removal of invasive species	2.50

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5	Conservation Plan for Wildlife (Schedule – I)	68.00
6	Wildlife survey & research	
(i)	Survey of wildlife & wildlife habitats	2.00
(ii)	Survey for sensitive / unique wildlife habitats area in the catchment area.	1.00
7	Development of habitat improvement measures in the degraded areas	
(i)	Construction of watch Towers and Drinking water ponds for wildlife	2.00
(ii)	Vaccination and Medical facilities to domestic cattle	3.00
	Total	**99.00**

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Annexure – IV: Copy of Letter submitted to CWLW that all the components of the project are outside the WLS

Received copy

यूजेवीएन लिमिटेड

(उत्तराखण्ड सरकार का उपक्रम)

कार्यालय–महाप्रबन्धक (सिविल डिजाइन एण्ड हाइड्रोलोजी एवं नई परियोजनायें), गंगा भवन, यमुना कालोनी,
देहरादून–248001 (उत्तराखण्ड), दूरभाष: 0135–2531700, फैक्स सं0: 0135–2530489

ISO 9001:2008 Certified

पत्रांक: 52 / यूजेवीएनलि / 03 / निदे.(परि.) / मप्र(नई परियोजना) / एसबीआर दिनांक: 02.03.2021

सेवा में,

मुख्य वन्य जीव प्रतिपालक
वन विभाग,
85, राजपुर रोड
देहरादून, उत्तराखण्ड।

विषय: सिरकारी भ्योल रूपसियाबगढ़ जल विद्युत परियोजना (120 मेगावाट) के सभी संरचनाओं के अस्कोट वन्यजीव विहार से बाहर होने सम्बन्धी प्रमाण पत्र निर्गत करने के सम्बन्ध में।

सन्दर्भ: मुख्य वन संरक्षक, अनुश्रवण, मूल्यांकन,आई.टी. एवं आधुनीकीकरण का पत्रांक संख्या 1145 / 32–1–1(जी.आई.एस.) दिनांक 30.12.2020 (छायाप्रति संलग्न)।

महोदय,

उपरोक्त विषयक आपको अवगत कराना है कि उत्तराखण्ड राज्य के पिथौरागढ जिले में स्थित सिरकारी भ्योल रूपसियाबगढ़ परियोजना के विकास का कार्य यूजेवीएन लिमिटेड द्वारा किया जा रहा है। जिस हेतु पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार द्वारा निर्गत ToR के आधार पर परियोजना की पर्यावरणीय प्रभाव आकंलन एवं पर्यावरणीय प्रबन्धन योजना तैयार की गयी एवं परियोजना हेतु जन सुनवाई की प्रक्रिया पूर्ण की जा चुकी है।

परियोजना की पर्यावरणीय स्वीकृति हेतु दिनांक 05.02.2021 को आहुत बैठक में पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय द्वारा गठित विशेषज्ञ मूल्यांकल समिति के समक्ष प्रस्तुतिकरण दिया गया एवं उक्त पर चर्चा की गयी (बैठक के कार्यवृत्त की छायाप्रति संलग्न)।

विशेषज्ञ मूल्यांकल समिति द्वारा यूजेवीएन लि0 से निम्नलिखित बिन्दु पर अनुपालन करने हेतु निम्नलिखित अनुशसा की गयी है:–

Point 8. Certificate from the Chief Wildlife Warden that all the components of the project are outside the Askot Wildlife Sanctuary (WLS) or any other WLS.

अवगतनीय है कि मुख्य वन संरक्षक के उक्त संदर्भित पत्र के माध्यम से सिरकारी भ्योल रूपसियाबगढ़ परियोजना की अस्कोट वन्यजीव विहार की से हवाई दूरी (जो कि 21.4 किमी है) के सम्बन्ध में प्रमाण पत्र पूर्व में निर्गत किया जा चुका है (छायाप्रति सुलभ सन्दर्भ हेतु संलग्न)।

उक्त तथ्यों के दृष्टिगत आपसे अनुरोध है कि परियोजना की सभी संरचनाओं के अस्कोट वन्यजीव विहार से अथवा किसी अन्य वन्यजीव विहार से बाहर होने सम्बन्धी प्रमाण पत्र निर्गत करने का कष्ट करें।

संलग्नक: उपरोक्तानुसार

(ओ0 पी0 सिंह)
महाप्रबन्धक (जानपद–नई परियोजनायें)

पत्रांकः /यूजेवीएनलि/03/निदे.(परि.)/मप्र(नई परियोजना)/एसबीआर तददिनांक ।

प्रतिलिपि निम्नलिखित को सूचनार्थ प्रेषितः–

1 निदेशक (परियोजनायें), यूजेवीएन लिमिटेड, महारानी बाग, देहरादून।
2 उपमहाप्रबन्धक, सिरकारी भ्योल रूपसियाबगढ़ जल विद्युत परियोजना, कैन्ट रोड, जाखनी, पिथौरागढ
3 उपमहाप्रबन्धक (अनु. एवं नियोजन तथा किसाऊ परियोजना), गंगा भवन, यमुना कालोनी, देहरादून।

(ओ0 पी0 सिंह)
महाप्रबन्धक (जानपद–नई परियोजनायें)

कार्यालय
मुख्य वन्यजीव प्रतिपालक
उत्तराखण्ड, देहरादून

पत्रांक -R.No.9182 /124 दिनांक 03/03/2021

प्रतिलिपि सह संलग्नक प्रभागीय वनाधिकारी, पिथौरागढ़ वन प्रभाग, पिथौरागढ़ को प्रकरण का परीक्षण कर आख्या अपने मन्तव्य के साथ उपलब्ध कराते हुये प्रेषित।

संलग्नः- उपरोक्त।

मुख्य वन्यजीव प्रतिपालक
उत्तराखण्ड, देहरादून
3/3/21

कार्यालय प्रभागीय वनाधिकारी, पिथौरागढ़ वन प्रभाग, पिथौरागढ़।

E-mail: dfopithoragarh@rediffmail.com Fax &☎ 05964- 225234

पत्रॉक 3704 /12-1 दिनांक, पिथौरागढ़, 18 मार्च, 2021।

सेवा में,

मुख्य वन्यजीव प्रतिपालक,
उत्तराखण्ड, देहरादून।

विषयः– **सिरकारी भ्योल रूपसियाबगड़ जल विद्युत परियोजना (120 मेगावाट) के सभी संरचनाओं के अस्कोट वन्यजीव विहार से बाहर होने सम्बन्धी प्रमाण पत्र निर्गत करने के सम्बन्ध में।**

संदर्भः– आपका पत्रांक –R.No. 9182/12–1 दिनांक 03–मार्च–2021।

महोदय,

उपरोक्त संदर्भित पत्र के अनुपालन में सादर अवगत कराना है कि उप वन संरक्षक के कार्यालय पत्रांक 1145/32–1–1 (जी0आई0एस0) देहरादून दिनांक 30–09–2020 के द्वारा यूजेवीएन लिमिटेड के प्रस्तावित सिरकारी भ्योल रूपसियाबगड़ जल विद्युत परियोजना (120 मेगावाट) की अस्कोट वन्यजीव अभ्यारण्य की निकटतम सीमा से हवाई दूरी 21.4 कि0मी0 आंकलित की गई है।

उपरोक्त के क्रम में यह सत्यापित किया जाता है कि परियोजना के सारे अवयव अस्कोट वन्यजीव अभ्यारण्य एवं अन्य किसी भी वन्यजीव अभ्यारण्य की परीधि से बाहर है।

भवदीय,

प्रभागीय वनाधिकारी,
पिथौरागढ़ वन प्रभाग, पिथौरागढ़।

Annexure – V: Undertaking by the Project Proponent regarding the slope stability.

यूजेवीएन लिमिटेड

(उत्तराखण्ड सरकार का उपक्रम)

UJVN LIMITED

(A Govt. of Uttarakhand Enterprise)

कार्यालय-महाप्रबंधक (सिविल डिजाइन एण्ड हाइड्रोलोजी एवं नई परियोजनायें), गंगा भवन यमना कालोनी, देहरादून-248001 दूरभाषः 0135-2531700, फैक्स सं0 0135-2530489

General Manager (CDH & New Projects) "Ganga Bhawan", Yamuna Colony, Dehradun-248001 Ph No-0135-2531700 Fax No.0135-2530489

CIN No.U40101UR2001SGC025866

ISO 9001,14001 Certified

Name of the project:Sirkari Bhyol Rupsiabagar HEP (120MW)

Address:General Manager(CDH&NP),UJVN Ltd,Ganga Bhawan,Yamuna colony,Dehradun 248001

e-mail/contact No:gmcdhnp.27.8.2019@gmail.com/9456590100

Undertaking

This is to certify that following provisions have been made under Muck Management Plan in the EMP report of Sirkari Bhyol Rupsiabagar HEP (120MW) taking into consideration proper stability of slopes of the foreseen muck piles.

Requisite Engineering and Biological measures shall be evolved and implemented to stabilize the profile of muck piles as per the engineering design requirements with appropriate supporting structures like, GI wire crates, retaining walls (R. R. stone masonry retaining wall/Gabion wall/RCC counterfort retaining wall). The retaining walls shall be kept at least 30 mtr. away from the point of HFL of the river with hill slope.Dumped muck shall bespread manually behind the wall. The muck shall be laid vertically not exceeding 28 degree so that the rock mass is properly stacked behind the wall with minimum of Voids. Apart from the Engineering measures, Biological measures shall also be implemented. The muck piles shall be covered with geo –coir textiles,afforestation of suitable species of herbs, shrubs & trees adaptable to local conditions in consultation with state forest deptt. Close monitoring of muck disposal sites shall be done and guidelines of MoEF & CC and UKPCB in this regard shall be followed.

(O PSingh)
General Manager(CDH & NP)